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Conference Proceedings



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Confirmation of the Review Process (for SA Authors)

To whom it may concern,

The digiTAL 2023 conference was hosted in Cape Town, South Africa, in association with Victorian Institute of Technology, Australia; The Independent Institute of Education, South Africa; and e-Merge Africa, South Africa; from the 6th to the 7th of December 2023, at the Southern Sun, Newlands Hotel.

The conference proceedings aims to disseminate original research and new developments in the field of digital teaching, learning and assessment across multiple disciplines. Complete articles were double blind peer reviewed prior to acceptance for presentation at the conference, and subsequent publication in the proceedings. The related International Standard Book (ISBN) is 978-0-6397-8100-6 (e-book). The target audience of the proceedings are specialists in the field of digital teaching, learning and assessment. More than 60% of contributions published in the conference proceedings emanate from multiple institutions. The conference has an editorial board ([see Pg.viii](#)) and/or organising committee ([see Pg.x](#)), with a significant majority of members beyond a single institution, which is reflective of expertise in the field of digital teaching, learning and assessment.

Regards,



Prof Sid Nair
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Date: 31st December 2023

Editorial

digiTAL 2023 is the fourth edition of the international conference on Teaching, Assessment and Learning in the Digital age and was held in Cape town, South Africa. The theme for 2023 is “Purposeful Outcomes for Digital Delivery”.

The 2023 conference had , a total of 130 submissions were submitted from South Africa, Nigeria, Mauritius, Australia , Eswatini, Namibia, Ghana, Zimbabwe, Ireland, Kenya, and Nigeria. The outcome of this overwhelming response has a conference proceeding with 27 fully double-blind refereed papers. 65 submissions were accepted for presentation at the conference.

In this proceeding the 27 full papers cover a broad spectrum of topics; lecturer evaluation/peer review of teaching, micro-credentials, ChatGPT, digital gap for students with disabilities, skill sets as define by the 4th industrial revolution, personalised learning pathways, computing engineering and technology, influence of social media, smart technology integration, big data, machine learning, artificial intelligence, digital photos, eLearning platforms, effects of load shedding, academic misconduct/ integrity, cloud computing and discipline specific pedagogy.

In the paper *Determinants for measuring lecturers’ performances in Higher Education: Students perspectives*, the authors Anele, Okonkwo & Asmal looked at the factors that influence how lecturers are evaluated in higher education in areas such as concept delivery, motivation, feedback, consultation, preparedness, teaching method, learning environment, equality, and skill acquisition. The findings suggest that these factors have an impact on the evaluation process with respect to lecturers’ performance.

Mahlasela & Steyn’s paper on *Challenges of adopting micro-credentials for skills development in South Africa: A literature review*, of 55 articles on micro credentialing provided some recommendations to assist employers and employees when adopting micro-credentials for skills development. These recommendations included a recognition framework, enhanced quality assurance and the promotion of transferability and stackability.

The paper by Thomas entitled *Investigations into ChatGPT using first-level programming MCQs* looked at if ChatGPT can respond to MCQs, the accuracy of explanations, the ability to identify the questions' Bloom's taxonomy level, and its capacity to generate questions of a similar nature. The paper concludes with the need to have guidelines for educators on the design and formulation of MCQs with the presence of ChatGPT in the teaching and learning arena.

Orim, Adigun & Ashike in their paper *Digital divide: A threat to digitalization of teaching-learning process for students with disabilities in Nigerian Universities* investigated the digital technology gap in the Nigerian universities for students with disabilities. The result showed that the sociodemographic disparity in terms of digital access between students with disabilities and those without is unreasonably wide. The study provided recommendations one of which is the need for the universities in Nigeria to set up a digital technology culture through diverse programmes and engagements with relevant stakeholders so as to bridge this gap.

The paper entitled *Skills required in higher education to prepare graduates for the Fourth Industrial Revolution workforce* is presented by Seshoka, Malan and Xaba. This paper reviewed the skill set

needed for the employment of South African graduates during the Fourth Industrial Revolution. The study suggested that none of the qualifications at a university South Africa had not incorporated all the identified skills for the fourth industrial revolution. The paper recommends that a unit be introduced to cover the identified skills which have not been incorporated.

Ntlangula & Wai Sze in their paper *Examining the readiness of learning management systems in developing personalised learning paths* examines the literature on the Learning Management Systems at twenty-six public universities in South Africa. The studies aim was to examine the readiness of these Learning Management Systems to create effective personalised learning paths. The study suggests that the data collected through the Learning Management Systems alone is insufficient for informed learning and teaching customisation decisions.

In the paper, *Exploring the heart of peer review of teaching: a qualitative study in a private higher education institution*, Heine's, qualitative study explored the experiences and reflections of lecturers and reviewers who participated in a peer review of teaching practice in a private higher education institution in South Africa. The finding of the study suggests, the “intersubjective nature of the relationship and provision for dialogue around reviewer feedback are significant determinants in the peer review process being experienced as valuable”.

Mosai presents four papers in these proceedings. The first paper on *The impact of computing technology on the future of Industrial Engineering: A South African perceive in the Universities of Technology*, looked at the impact of computational tools on the future of IE and the approach taken in engineering education. The study suggests that engineering curriculum does not provide a competitive advantage in the current environment. In the second paper on *A practical skills-based pedagogy in engineering education*, Mosai presents a qualitative research to explore and explain how engineers are trained to enable graduates to successfully transition into new occupation, with relevant graduate attributes required in industry. The study suggests that such skills are embedded in the engineering curriculum. In the third paper, *Towards resilient manufacturing through smart technology strategies*, Mosai presents a paper on the concept of resilient manufacturing and explores strategies for achieving it through smart technology integration. The final paper by Mosia, *Application of big data, machine learning, and artificial intelligence strategies in healthcare data processes optimization*, describes a data processing improvement event achieved through the application of big data strategies in the patient affairs and data management faculty of a public hospital. The research reports the need to address the challenges in realising the full potential of big data strategies and tool in healthcare service delivery systems.

Odit-Dookhan paper on *The use of social media and the academic performance of undergraduate university students in Mauritius*, explored the impact of the use of social media on academic performance among undergraduate students in Mauritius. The results of this study suggest that students used social networking sites for educational and non-educational purposes with social media having significant positive relationship with the students' academic performance.

In the paper *What happens to the photos they take? An investigation into how programming students utilize photographs taken during lectures at a South African private higher education institution*, Adam, sought to understand how programming students utilise the photographs they take in class and the reasons for opting for photographs instead of writing or typing out notes. The findings indicate that students take photographs of content that they consider important for future use.

Motjoloane presents a paper entitled *Examining big data sources for enhanced disease surveillance in South African public healthcare*. This paper investigates various sources of big data that can augment traditional disease surveillance strategies in public healthcare. The findings suggest that the diverse data sources offer opportunities for real-time analysis.

Another paper on big data analytics, entitled, *Investigating the influence of big data analytics on the campaign outcomes of political parties, South Africa: A scoping review*, the authors Tibatshi and Ramafi investigate the influence of Big Data Analytics (BDA) on the campaigns of political parties in Africa. The study suggests that the legal system are hurdles that have been addressed if BDA is to be utilised effectively.

Maharaj and Pillay present a paper entitled *An evaluation of digital and artificial intelligent tools in an electronic and computer engineering curriculum at a university of technology in South Africa*. This study explored the adoption and impact of digital tools in engineering education. This research paper adds to the literature on the optimisation of digital tools for personalised learning and collaborative education in engineering programs.

Butgereit, research titled *Prof Pi: GPT-4 tutoring mathematics in African languages*, looked at a chaGPT based mathematics tutoring bot, Prof Pi. The study suggest that this tool is useful in helping students in their mathematics.

The paper on *The students' and lecturers' experiences in the use of GIT in IT courses in a HEI* by Rakgogo and Joseph, explored students' and lecturers' experiences in the use of Git in the Information Technology (IT) course in a HEI in South Africa. The research paper suggests a number of benefits which include ease of use of Git, familiarity with other platforms, and the capacity of the learners to use GitHub and their experiences for project submission.

Jospeh and Rakgogo in their paper titled *The students' experiences of using cloud technologies in a HEI during Covid-19 lockdown*, report the positive influences and experiences of cloud technology in the teaching and learning.

The paper by Mdingi and Govender entitled *The effects of digitalisation on assessing learning outcomes in Accounting* report on how digitalisation affected the assessing of learning outcomes in an accounting module. The paper suggests that there were difficulties in terms of upholding the integrity of online assessments and the available question types on Learning Management Systems did not fully accommodate the needs of accounting subjects.

Thulare, Maremi & Herselman in their paper titled *A scoping review of applying the Delphi method based on how the COVID-19 pandemic impacted conducting research*, looked at the “evidence of the use of the Delphi method to add value to research and replace face-to-face interviews based on the impact and restriction of COVID-19 pandemic”. The study concluded that the Delphi method is more suitable for identifying, verifying, and validating the study's outcome in situations where face-to-face access to participants is not possible and participants are based in different locations.

Mthethwa, Nthatheni, Maremi & Thulare paper on *Recommendations for sustainable post COVID-19 eLearning development in Rural Schools in South Africa*, discusses the various factors that contributed to the failure to sustain ICT initiatives. The study suggests four major factors affecting sustainability of ICT initiatives; physical, management, social, and educational conditions.

In the paper by Simelane-Mnisi titled *Effectiveness in maintaining academic integrity while using online proctoring for online assessment*, investigated the effectiveness of maintaining academic integrity while using online proctoring for online assessment. The findings suggest that though the proctoring tool is generally beneficial, it still did not prevent students from cheating.

Okonkwo, Anele & Shikari in their paper on *Evaluation of the performance and experience of the students learning with AI systems*, investigated students' learning experiences and perceptions of existing AI systems. The study suggests that using AI systems in teaching and learning is beneficial and improves their learning experiences.

In the paper by Deliwe and Khumalo on *The importance of Learner Management Systems in enhancing knowledge management within Higher Education Institutions*, the authors present a conceptual paper where literature on Learning Management Systems enhancing knowledge management is reviewed.

The paper on *Preparing first year programming students for future studies by mitigating source code plagiarism* by Smit, investigates source code plagiarism. The paper delves into the use the identification of source code plagiarism as an opportunity to teach students about plagiarism, in the context of programming.

Pillay, Okonkwo & Anele in their paper on *The impact of loadshedding on student academic performance: A data analytics approach* investigates the effects of loading shedding on academic performance in the Sout African educational system. The study concluded that Loadshedding has significant impact on the academic performance of higher education students.

Finally, our thanks go out to the keynotes who have made time to enlighten us with their knowledge and experience and our collaborators of this conference, the Victorian Institution of Technology, e/Merge Africa, South Africa, and the Independent Institute of Education, South Africa.

Professor Sid Nair (Victorian Institute of Technology, Australia)
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Determinants for measuring lecturers' performances in Higher Education: Students perspectives

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Abstract

The introduction of technology such as Artificial Intelligence (AI) has caused changes in many areas of life, including education. The higher education system fosters an environment in which students can learn and lecturers can teach to achieve national development goals. Lecturers are required to prove their skills or competency by applying some set of attitudes, behaviours, and techniques in the teaching and learning environment to achieve the expected learning experiences. Understanding the factors that influence the efficiency of a lecturer during classroom activities will aid in evaluate the performance of the lecturer. The appraisal and performance management are now major concerns in higher education. A lecturer's job is demanding and competitive, necessitating an effective performance evaluation based on key determinants. This study looked at the factors that influence how lecturers are evaluated in higher education. Several factors were investigated, including concept delivery, motivation, feedback, consultation, preparedness, teaching method, learning environment, equality, and skill acquisition. A survey was conducted using a questionnaire as an instrument of data collection. The collected data was analysed using standard statistical analysis software. The findings show that most of these factors are perceived to have a significant impact on the evaluation of lecturers' performance in higher education by the participants. These findings make theoretical and practical contributions by revealing more about students' perceptions of the factors used to evaluate lecturers' performance and assisting higher education institutions with the lecturer evaluation process.

Keywords: Determinants, Lecturer Performance, Higher Education, Students

Introduction

Lecturers have an important role in creating students' learning experiences and academic results in higher education. As educational institutions strive for excellence, reviewing and monitoring the performance of lecturers becomes increasingly important (Kahn et al., 2021). While there are many aspects to consider when evaluating a lecturer's success, one important viewpoint that is sometimes overlooked is that of the students themselves.

Higher education institutions across the world have long acknowledged the value of measuring teaching quality. Evaluating lecturers' performance assists in identifying areas for development, rewarding excellent teaching approaches, and eventually improving the

learning environment (Vilela et al., 2019). Historically, universities used a variety of evaluation methods, including student feedback questionnaires, peer observations, and self-assessment. Understanding students' unique viewpoints and incorporating their opinions into performance assessments, on the other hand, might provide useful insights for improving teaching and learning outcomes.

Students' viewpoints are an important source of feedback since they have firsthand contact with lecturers' teaching techniques, classroom dynamics, and instructional approaches (Amerstorfer et al., 2021). Their observations can give information on lecturers' abilities in communicating complicated topics, stimulating debates, providing constructive comments, and promoting an engaging learning environment (Mandouit, 2018). Higher education institutions should guarantee that the evaluation process coincides with the aim of fostering good teaching methods and student achievement by including students' viewpoints into performance assessments (Rahardia et al., 2020). According to Darling-Hammond (2017), it is valuable to examine teachers' performances. To achieve this, there is need to consider some influencing factors.

Identifying the elements that impact students' assessments of lecturers' performance is an important step in incorporating their perspectives into evaluation systems. These factors might include concept delivery, motivation, feedback, consultation, readiness, teaching approach, learning environment, equality, and skill acquisition (Owuor et al., 2013; Hwang et al., 2020; Ade-Ibijola and Okonkwo, 2023). Institutions can design assessment frameworks that capture a holistic perspective of lecturers' performances by identifying the variables that students find critical for good teaching.

Recognising the importance of students' perceptions in assessing lecturers' performances, this study seeks to identify the determinants for measuring lecturers' performances in higher education from students' perspectives. As a result, the research question is, "*What factors determine a lecturer's effectiveness in the classroom?*" By taking these factors into account, higher education institutions may improve their assessment procedures and establish a more student-centred approach to evaluating lecturers' work.

This research makes substantial contributions to both theory and practice. First, including students' viewpoints in the evaluation of lecturers' work in higher education is critical for building a strong teaching and learning environment. Second, by knowing the variables that students value, institutions may improve their assessment processes and guarantee that teaching practices are in line with student demands. Third, by aiming for continual improvement based on student input, higher education institutions may build an excellence culture and deliver the best educational experience possible for all students.

Background information

This section presents the theoretical overview of the topic under study including lecturer's performance and its importance as well as brief description of the potential factors that may influence the measuring of lecturer's effectiveness.

Lecturers' performances

Lecturer performance in higher education refers to the evaluation and assessment of a lecturer's efficacy as an educator in a higher education context. It includes a variety of elements that contribute to their capacity to give excellent education, engage students, encourage learning, and support student achievement (Rahardia et al., 2020). The performance of lecturers is critical to generating a pleasant learning environment, encouraging student participation, and enabling the acquisition of information and skills (Abdulrahman et al., 2020; Rahardia et al., 2020)

The effectiveness of lecturers in higher education is critical in shaping students' learning experiences and academic outcomes (Rahardia et al., 2020). The efficacy of lecturers has a direct impact on the entire educational environment and the quality of instruction in higher education institutions. Evaluating and enhancing the performance of lecturers is critical for ensuring effective teaching, encouraging student participation, and enabling student achievement. Several important aspects contribute to monitoring and improving the performance of lecturers in higher education. Some of the important aspects include:

Concept Delivery - The process of effectively expressing difficult concepts, theories, or principles to an audience during a lecture or presentation is referred to as concept delivery in lecturing (Maphosa et al., 2020). It entails organizing and presenting information in a clear, engaging, and orderly manner to aid comprehension and knowledge retention. Effective idea delivery in lecturing is more than just passing on knowledge. It is about designing an interesting and dynamic learning environment that promotes comprehension, critical thinking, and information retention. If lecturers are compelled to account for students' performances, they will design better ways to deliver the course content to enable students to achieve their academic goals (Gilbert, 2018). Considering the relationship between content delivery and students' academic achievements, the following hypothesis is proposed.

H1: *Content delivery has positive influence on lecturers' performances.*

Motivation - Student motivation is the intrinsic drive, ambition, and passion that students have for studying and accomplishing academic goals. Students who are motivated are more likely to be interested, persistent, and actively involved in their education. Student motivation can be influenced by a variety of factors, and it varies across individuals. Flexibility, adaptability, and a student-centred approach can all help create a great and stimulating learning experience during lectures. Lecturers are still important in the student learning experience because they develop, educate, and construct the ideas that shape the student learning experience (Wong and Chiu, 2020). According to Kariuki et al., (2018), teacher motivation has a significant impact on students' academic achievements. Considering the impact of lecturer on student learning experience, the following hypothesis is proposed.

H2: *Student motivation to learn has a significant impact on lecturers' performances.*

Feedback - One of the most important aspects of the teaching and learning process is giving students insightful feedback (Martin and Bolliger, 2018; Rahardia et al., 2020). A focus on student development and improvement, active listening, and open communication are all essential components of an effective feedback process. Lecturers can enhance students'

learning processes and encourage continual progress by giving timely, precise, and actionable feedback (Kulikowski et al., 2021). There is a considerable relationship between feedback subjects and student performance, and instructors most commonly offer feedback relating to student evaluation improvement (Salehian et al., 2022). Considering the feedback to students, the following hypothesis is proposed.

H3: Active feedback influences lecturers' performances.

Consultation - Student consultation is an essential component of good teaching and learning (Byun et al., 2018; Neighbour, 2018). It entails allowing students to engage in one-on-one or small group talks with lecturers to seek assistance, clarification, or further support. Lecturers may give tailored help, address specific needs, and enable students to take control of their learning through effective student consultations. This individualized contact improves learning and encourages academic achievement. Consultation influences students and educators' performances (Meyers et al., 2017). Considering the importance of consultation in teaching and learning, the following hypothesis is proposed.

H4: Student consultation is a critical factor in measuring lecturers' performances.

Teaching method - A lecturer's teaching technique is an important aspect of evaluating their performance. The effectiveness with which a lecturer deploys diverse teaching strategies may have a major impact on students' learning experiences and outcomes (Allen et al., 2020). Instructor evaluations should be carried out in a thorough and well-structured manner, taking into consideration numerous viewpoints such as student feedback, peer observations, self-assessment, and statistics on learning outcomes. A balanced evaluation of a lecturer's performance based on their teaching approaches will assist in identifying areas of strength and areas for improvement, resulting in continued professional growth and improved teaching effectiveness (Darling-Hammond et al., 2013). Considering the use of various teaching methods teaching purposes, the following hypothesis is proposed.

H5: Teaching methods are essential for lecturers' effectiveness in the classroom.

Learning environment – The teaching environment involves the physical, social, and psychological settings in which teaching and learning take place (Broadbent and Poon, 2015). The learning environment is an important consideration when evaluating a lecturer's performance. A happy and supportive learning environment may have a significant impact on students' engagement, motivation, and academic performance. Several studies confirm that learning environment influences students' academic performances (Thai et al., 2017; Waheed et al., 2020). Feedback from students, peer assessments, and self-assessment can give useful insights into the quality of the learning environment when evaluating a lecturer's performance. A complete evaluation considers how well the lecturer develops a pleasant and conducive learning environment that encourages student participation, motivation, and academic accomplishment. Considering the important of learning environment in education, the following hypothesis is proposed.

H6: Learning environment influences lecturers' performances in the classroom.

Equality – In the classroom, equality is a critical component that determines lecturer performance and teaching results. The equality of differentiated instructions influences students' academic achievements (Valiandes et al., 2015). Lecturers may thrive in their

professions by providing an inclusive and fair learning environment, which leads to improved student learning experiences and academic performance. To provide the greatest possible outcomes for all stakeholders, institutions and educators must collaborate to remove prejudices and promote equality (Eddy et al., 2015). Considering the role of equality in teaching, the following hypothesis is proposed.

H7: *Equality in classroom has a significant impact on lecturers' performances.*

Skill acquisition – Skill acquisition may, in fact, be used to assess lecturers' performance in the classroom. Assessing lecturers' skill acquisition might give significant insights into their performance as instructors. Skill acquisition improves employee performance and organisational productivity (Ibrahim et al., 2017). According to Tang (2020), soft skills are important features of lecturers in higher education. A holistic knowledge of lecturers' teaching efficacy is ensured by a complete method to evaluate their performances, which includes skill acquisition and encourages a culture of continual improvement in higher education institutions. Considering the important of skill acquisition in teaching, the following hypothesis is proposed.

H8: *Skill acquisition is important factor that can determine lecturers' effectiveness in teaching process.*

Research conceptual model

For the study, a three-component model was developed that included student perspectives, measuring factors, and lecturers' performances. According to the model, evaluating the performance of lecturers from the perspective of students begins with first, collecting data from students' perceptions of lecturers during classroom activities based on some potential determining factors; and second, adequate analysis of the collected data can provide the required result for the study—the determinants for measuring lecturers performances in higher education.

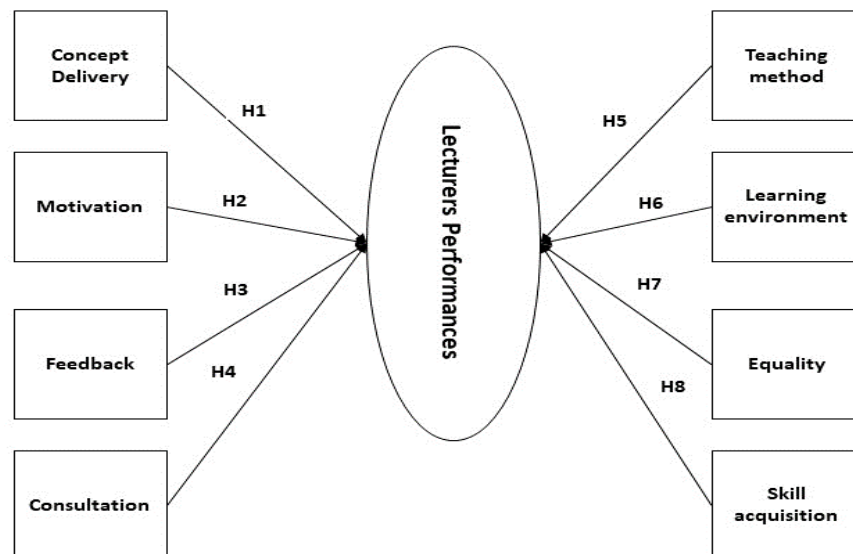


Figure 1: Research conceptual model (Authors compilation)

Research methodology

The purpose of this study is to determine the factors that influence the performance of lecturers in the classroom in a higher education setting from the students' perspectives. It is therefore imperative to obtain quantitative data from the participants. Hence, positivist research principles were followed. A cross-sectional survey was conducted using a questionnaire through online platform to collect self-determined data from the participants without the researchers' influence. The survey was developed using indicators derived from previous studies that tailored on lecturers' performances (Valiandes et al., 2015; Ibrahim et al., 2017; Kariuki et al., 2018; Byun et al., 2018; Maphosa et al., 2020; Rahardia et al., 2020; Allen et al., 2020; Waheed et al., 2020). A 5-point Likert scale (1–5: 1—strongly disagree and 5—strongly agree) was used for measurements. The questionnaire was pre-tested to ensure that it met the research objectives. All the feedback was considered, and changes were made as a result. The pilot test was used to measure the robustness of the proposed model before performing the final data collection stage. Since the study was based on the lecturers' performances, the students and staff in higher education were the target audience. The population was chosen using non-probabilistic sampling techniques, including purposive and convenience methods. Because the researchers could not cover the expected sampling frame, it was critical to select a sample population that included all the targeted audience. As a result, the purposive technique was necessary. The researchers were unable to access everyone in the intended sample population except those who were readily available; at this point, the convenience method became important and was also used. The purposive strategy was used to choose higher educational institutions, and the convenience technique was used to gather data from the participants. A total of 720 responses were collected covering different genders and various age group.

Ethical considerations

This study was approved by the Institutional Ethics Committee (Approved No. FITREC230052). The participants were duly informed about the purpose of the study and the research protocol.

Reliability analysis

Cronbach's alpha coefficient analysis was used to assess the reliability of the study variables, and the factors were found to be internally consistent (> 0.90). All the correlation ratings are the same ($r = 1$), indicating a strong correlation between the factors. This is possible because the study was conducted in a unique domain—a higher educational context with similar perceptions and attitudes among participants. Table 1 displays the reliability test results.

Table 1: Reliability analysis

Research Variables	Cronbach Alpha (α)
Concept delivery	0.94
Motivation	0.94
Feedback	0.94
Consultation	0.95
Teaching method	0.94
Learning environment	0.94
Equality	0.95
Skill acquisition	0.94

Survey results

A survey was conducted to obtain the participants perceptions of lecturers' performances during teaching and learning activities. The survey results are presented below.

Participants' information: In this section the formation of the sample population is described covering gender, age group, and status (students or staff). See Table 2.

Table 2: Participants' information

Gender				
Male				Female
396 (55%)				324 (45%)
Age Group				
15 – 25 (78%)	26 – 35 (12%)	36 – 45 (6%)	46 – 55 (4%)	
Status				
Students			staff	
641 (89%)			79 (11%)	

Lecturers' performances: This examined the general perceptions of the participants about the importance of lecturers' performances. 93% of the participants agreed that lecturers' performances are essential for student academic achievements. 2% disagreed and 5% were neutral.

Determinants of lecturers' performances

The section investigated the participants perceptions of lecturers' performances with regards to the identified factors. The obtained results are displayed in in Table 3.

Table 3: Determinants of lecturers' performances

Factors	Participants responses (%)		
	Agreed	Disagreed	Neutral
Content delivery	83	6	11
Motivation	79	13	8
Feedback	71	10	19
Consultation	74	18	8
Teaching method	91	2	7
Learning environment	88	7	5
Equality	69	20	11
Skill acquisition	87	10	3

Multi linear regression analysis

A multi regression analysis was performed to determine the relationship between lecturers' performances (dependent variable) and the determining factors (content delivery, motivation, feedback, consultation, teaching method, learning environment, equality, skill acquisition). The results are showed in Table 4.

Table 4: Multi regression analysis

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Tolerance	VIF
	B	Std. Error	Beta				
(Constant)	-.273	.076		-3.598	.001		
Content delivery	.202	.025	.196	8.211	.002	.238	4.205
Motivation	.054	.022	.047	2.448	.015	.371	2.694
Feedback	.026	.024	.023	1.074	.283	.295	3.385
Consultation	.012	.019	.011	.626	.532	.455	2.199
Teaching method	.155	.022	.165	7.187	.003	.255	3.915
Learning environment	.130	.026	.124	5.007	.012	.220	4.541
Equality	.012	.023	.009	.511	.610	.459	2.180
Skill acquisition	.479	.020	.481	24.352	.011	.345	2.896

Discussion

The purpose of this study is to determine the factors that may influence lecturers' performances in higher education settings. The indicators were indicators derived from previous studies that tailored on lecturers' performances (Valiandes et al., 2015; Ibrahim et al., 2017; Kariuki et al., 2018; Byun et al., 2018; Maphosa et al., 2020; Rahardia et al., 2020; Allen et al., 2020; Waheed et al., 2020). The research conceptual model was developed to show the relationship between the factors and lecturers' performances. Thus, the model was applied to address the research question: *What factors determine a lecturer's effectiveness in the classroom?* Through a survey, the quantitative data was collected from the sample population. The data was cleaned, extracted, and adequate statistical analyses were performed to obtain the required results.

This study's sample population was made up of 55% males and 45% females. This implies that the gender components (male and female) are roughly balanced. The higher education environment consists of different genders. This study included people ranging in age from 15 to 55, and all age groups participated in varying proportions. The majority of the participants were between the ages of 15 and 25. It implies that the vast majority of participants were students. This is encouraging because student perceptions of the use of lecturer's performances are required to meet study goals. Participants included students and faculty.

The results revealed that 93% of the participants agreed that lecturers' performances are essential for student academic achievements. This implies that the quality of lecturers' performances has a profound impact on students' academic achievements, learning experiences, and personal development.

Determinants for measuring lecturers performances in Higher Education

Several factors were identified in relation to lecturers' performances in previous studies. This study explored how these indicators can influence the performance of lecturers in the classroom.

Content delivery: According to the findings, 83% of the participants agreed that content delivery plays important role on the effectiveness of lecturers in classroom. This means that

material delivery is a critical component of lecturer performance that has a direct impact on students' engagement, understanding, and overall learning experience. Effective content delivery approaches enable lecturers to create a dynamic and interesting classroom atmosphere that promotes meaningful learning and favourable academic achievements. This finding is consistent with the suggestion that a good content delivery helps the students to achieve their academic goals.

Motivation: The study established that motivation is a key determinant of lecturers' performances. 79% of the participants totally agreed that motivation influences effectiveness in the classroom. In essence, student motivation may generate a positive feedback loop that improves both the learning experience and the lecturer's performance. When students are interested and motivated, instructors are more likely to thrive in their roles, resulting in a mutually beneficial partnership that promotes successful teaching. This result compares well with the finding of Kariuki et al. (2018), who concluded that motivation has a significant impact on students' academic achievements.

Feedback: The findings supported this hypothesis that posited adequate responsiveness to students' matters influences lecturers' performances. 71% of the participants totally agreed to this factor. This implies that lecturer feedback to students is a potent instrument that may have a considerable impact on lecturers' performance in the classroom. When lecturers offer constructive and timely feedback to their students, it fosters a good learning environment, increases student engagement, and promotes overall lecturer performance. The result agrees with the findings of (Kulikowski et al., 2021; (Salehian et al., 2022).

Consultation: Regarding this hypothesis, 74% of participants agreed that it has positive impact in determining lecturers' performances. Lecturer consultations, in essence, provide a significant outlet for personalised assistance and interaction, leading to improved lecturer performance and better student academic results. Lecturers may create a more inclusive, supportive, and effective learning environment that benefits both individual students and the entire classroom community by spending time and effort in these relationships. This finding concurs with the conclusions of (Meyers et al., 2017).

Teaching method: Concerning teaching method as a significant positive factor, 91% of the participants agreed that it influences lecturers' performances. This means that the lecturer's teaching strategies are critical to generating a productive and engaging learning environment. The correct strategies may improve student learning results, foster a happy classroom environment, and help lecturers improve their performance and reputation as professional educators. Lecturers may build a meaningful and effective learning experience for their students by continually analysing and changing their teaching approaches. This finding aligns well with suggestions of (Darling-Hammond et al., 2013; Allen et al., 2020; Okonkwo and Ade-Ibijola, 2021a).

Learning environment: 88% of the participants support this hypothesis that suggested that creating a good learning environment during teaching can improve lecturers' performances. This indicates that the learning environment creates a conducive setting for successful teaching and learning. A friendly, inclusive, and supportive environment may motivate

lecturers to flourish in their professions, modify their teaching techniques, and provide students with a meaningful educational experience. Higher education institutions can contribute to increased overall classroom performance by developing an atmosphere that prioritises both student and educator success. This result supports the findings of (Thai et al., 2017; Waheed et al., 2020).

Equality: Concerning this factor, 69% of the participants agreed that equal treatments of the students in the classroom promotes lecturers' effectiveness. This suggests that treating students fairly is not simply an ethical need but also a practical tactic that improves the entire teaching and learning experience (Okonkwo and Ade-Ibijola, 2021b). Lecturers who prioritise justice, inclusion, and respect create a learning environment in which students flourish, resulting in higher student performance and a positive cycle that supports lecturer effectiveness and job satisfaction. The finding agrees with the suggestions of ((Valiandes et al., 2015; Eddy et al., 2015).

Skill acquisition: 87% of the participant believed that being a subject matter expert of a course can influence lecturers' performances. In essence, talent acquisition is a continuous process that provides lecturers with the resources they require to flourish in their positions. Lecturers may create dynamic and successful learning environments that assist students while also contributing to their own professional progress and satisfaction by building a diversified skill set. The finding supports the suggestions of (Ibrahim et al., 2017; Tang, 2020).

Furthermore, a multi linear regression analysis was performed to determine the relationship between lecturers' performances and the determining factors. The model fits well with $R^2 = 90\%$. Figure 2 displays the obtained results in relation to the research conceptual model.

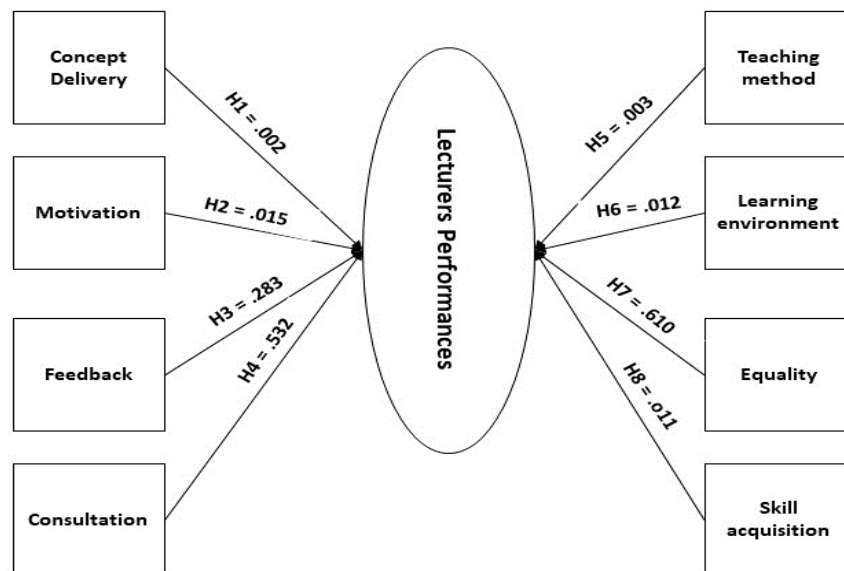


Figure 2: The level of the factors impacts the lecturers' performance.

According to Ellis and Steyn (2003), the criterion for practically significant results is a p-value < 0.05 . Five of the factors including content delivery, motivation, learning environment, teaching method, and skill acquisition have p-values < 0.05 (see Figure 3). The results indicate that these factors have the practical significant capabilities of predicting lecturers' performances in the classroom. The findings explained that effective content delivery, the provision of adequate encouragement to learn, creating a good learning environment, effective teaching strategies, and having advance knowledge of a subject have a practical impact on determining the performance of lecturers in the classroom.

Implications of the study

This study has both theoretical and practical implications. In theory, this study empirically investigated the determining factors that can influence lecturers' effectiveness during teaching and learning in higher educational institutions. Considering the little or no investigation on this aspect, the study contributes to theory. The finding could form the basis for further research. In practise, this study highlights the importance of lecturers' performances and provides more insights on the determinants of lecturers' performances in higher education. Adequate consideration of these factors will improve teaching capabilities, create effective student learning experiences, and improve the educational process in higher education.

Conclusions, limitations, and future works

This study investigated the determinants for measuring lecturers' performances in higher education. The factors were obtained from previous studies related to lecturers and students' academic performances. A research conceptual model was developed to depict the relationship between lecturers' performances and the identified factors. Through a survey, empirical data was obtained from 720 students and staff of higher education institutions. The statistical analysis indicates that all eight factors can influence the performance of lecturers. A multi-regression test confirmed that five of the factors, including content delivery, motivation, teaching method, learning environment, and skill acquisition, have significant practical capability to predict the lecturers' effectiveness in teaching and learning. This research study expands the current knowledge on the factors that can influence lecturers' performances and has substantial implications for improving higher educational systems.

Limitations and future works

Although the findings of this research work can be generalised, the study is limited to one institution in a country in Africa, South Africa. Other institutions and countries in Africa can be investigated. In addition, a cross-sectional approach was used in the study, which limited the research to a single viewpoint. Future works may apply the longitudinal study method to account for time variations.

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Challenges of adopting micro-credentials for skills development in South Africa: A literature review

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Abstract

Several studies reported the popularity of online education during the COVID-19 pandemic. Most people opted for short courses to develop new skills and reskill their capabilities. However, not everyone benefited from adopting micro-credential technologies, even though the literature emphasises the significant increase in online platforms. Therefore, this study investigated the challenges in adopting micro-credentials for upskilling or reskilling the workforce. A systematic literature review of fifty-five articles was conducted. After that, recommendations were formulated to assist employers and employees when adopting micro-credentials for skills development.

Keywords: Micro-credentials, Digital badges, Upskilling, Online Social Inclusion, Social Exclusion.

Introduction

Workforce development has become essential for organisations to improve productivity and employability in this digital age (Srija & Sanghi, 2018). The literature that writes on skills development uses different terms interchangeably to define workforce development, such as upskilling, reskilling, retraining, and many other words to describe new skills acquisition (Illanes et al., 2018; Paullet et al., 2020; Sanghi & Srija, 2015; Shirani, 2019; Sivalingam & Mansori, 2020; Srija & Sanghi, 2018). Hence, examining the upskilling and reskilling revolution is essential to understand which skill set will be needed for future work (Li, 2022; Wahab et al., 2021). Furthermore, introducing technologies such as big data, distributed ledger technologies, the Internet of Things, Artificial Intelligence, and Machine Learning has disrupted how we work and demands changes to business processes (Li, 2022). When considering technological advancements, companies will face the challenge of retraining their workforce (Abe et al., 2021; Sawant et al., 2022; Vidas et al., 2023).

Therefore, organizations should consider adopting technologies such as micro-credentials as catalysts for upskilling and reskilling both present and future workforce (Selvaratnam & Sankey, 2021). The implementation and use of micro-credentials have evolved in the past few years. According to Wu et al. (2015), micro-credentials originated from online forums and social media platforms to differentiate advanced users from average users. During their conception, many called them digital badges (Brands, 2002; Gibson et al., 2015; Wu et al., 2015). The origin of badges can be traced back to the Scout organisation that used images to

represent skills embedded in their Scout uniform (Trepulè et al., 2021; Wu et al., 2015). However, badges have evolved from images embedded in clothing to games where a player can get a digital badge to achieve a particular stage in the game (Lockley et al., 2016; Wolz et al., 2021).

To date, digital badges have been used on many platforms, including the education sector, to showcase learners' achievements (Carey & Stefaniak, 2018; Davis & Singh, 2015; Lockley et al., 2016). However, some employers are still reluctant to adopt micro-credentials when upskilling or reskilling employees (McGreal et al., 2022). Most studies highlighted that the misconception when defining micro-credential is still a problem, as many employers do not trust their credibility (Resei et al., 2019; Brown & Nic-Giolla-Mhichil, 2022; Hanafy, 2020).

Therefore, adopting micro-credentials in the workplace is not solely dependent on the employers (Oliver, 2019). But it requires the collaboration of other participants, such as micro-credential providers, policymakers, and high-education institutions (Oliver, 2019). Thus, standardisation is required when offering micro-credentials to ensure consistency across different providers (Selvaratnam & Sankey, 2021). Additionally, it is imperative for employers to consider integrating micro-credentials when training the workforce, as many employers still struggle with accepting digital credentials as a valid qualification (Kato et al., 2020; Zou et al., 2023). The study done by Brown & Souto-Otero (2020) stated that employers are more likely to hire candidates with a traditional qualification over those with a digital credential qualification when it comes to professional occupations.

Thus, this study aims to investigate the challenges in adopting micro-credentials for skills development in the workplace. A literature review was conducted to define and understand micro-credentials clearly. Afterwards, look at the challenges when adopting micro-credentials in the work environment. Then, finally, recommendations were highlighted to assist employers and employees in adopting micro-credentials for skills development.

Research methods

A systematic literature review was used to synthesise existing literature on Micro-credentials to understand the challenges of adopting micro-credentials when reskilling or upskilling employees. In total, fifty-five publications were retrieved, published between 2015 and 2023, for more comprehensive results. Scholarly databases used for extensive publication selection include Science Direct, Scopus, Springer Link, ACM Digital Library, and the Google Scholar search engine using the keywords 'Micro-credential' OR 'Digital badge' OR 'MOOC' AND 'Skill development'. The publications not available in full text and those not written in English were excluded from this study.

Literature review

It is essential to understand what the term micro-credentialing means. To break this down, Ehlers (2018) states that the word credential comes from the Latin word credence, which means credibility. Credibility based on learning outcomes is usually supported by evidence that an individual is competent and has been assessed in a field of study (Ehlers, 2018; Gibson et al., 2015). The literature has various concepts and definitions when defining micro-credentials, and they are often used interchangeably with words such as digital badges and

Massive Online Open Courses (MOOCs), just to name a few. Table 1 shows the different concepts of micro-credentials in the literature.

Table 1 Different terms and concepts of micro-credentials

Term	Definition	Concepts	Authors
Micro-credentials	Define micro-credentials as virtual, portable learning and skills that are acquired granularly.	A virtual representation of skills or knowledge	(Rimland & Raish, 2019)
	Credentialing that adopted competency-based professional learning to recognise learner skills and achievements.	Proof of skills, achievement, and competence	(Kilsby & Fountain, 2019)
	Mini certifications in specific areas of study or professional development will help to recognise the student's skills.	Demonstrates knowledge and skills earned through assessment-based activities.	(Lim et al., 2018)
Digital badge	The certification of the assessed learning is less than the formal qualification.	Assessed learning less than formal qualification	(Oliver, 2019)
	A representation of an accomplishment that is visual, available online, and contains metadata, including links that help explain the context and result of an activity.	Supports skill acquisition through performance.	(Gibson et al., 2015)
	A digital identity certificate that can be transferred electronically and can be verified with 100% accuracy by computers.	Equivalent to a tangible certificate issued by a trusted institution	(Brands, 2002)
Massive Open Online Courses (MOOCs)	A clickable graphic that contains an online record of achievement and information about the organisation or entity that issued the badge.	A solution modified to the needs of digital competence training offered in higher education.	(Borrás-Gené, 2018)
	Free online courses, which started collaboratively as tech-minded learning events.	MOOCs offer access to education.	(Lambert, 2020)
	They are designed to be free and openly accessible without grading or formal assessment.		(Zhu et al., 2018)
	Modern Internet-based teaching support with unrestricted access.		(Zhu et al., 2018)

Table 1 shows the different terminologies and understanding of micro-credentials. However, the concept of skills and knowledge earned as a form of recognition from an institution emerges (Kilsby & Fountain, 2019; Lim et al., 2018; Rimland & Raish, 2019). Other studies interchange micro-credentials and digital badges (Jirgensons & Kapenieks, 2018; Newby & Cheng, 2020). On the other hand, a digital badge is identified as an online image containing metadata equivalent to an actual certificate (Borrás-Gené, 2018; Brands, 2002; Gibson et al., 2015). When it comes to the concept of Massive Open Online Courses (MOOCs), there was mutual understanding, as they were identified as free online courses that anyone can access without prerequisites (Alalwan et al., 2019; Lambert, 2020; Zhu et al., 2018). Therefore, in

this study, the micro-credentials adopted terminology is a virtual representation of skills or knowledge earned.

Challenges of adopting micro-credentials in the workplace

Lack of recognition

Lack of recognition is one of the challenges to the adoption of micro-credentials in the workplace. The discrepancy in the definition of micro-credentials highlighted by different studies may potentially set a negative assumption to employers (Berry & Byrd, 2019; Paullet et al., 2020; Resei et al., 2019; Rimland & Raish, 2019; Rottmann & Duggan, 2021). Therefore, implementing standards for micro-credentials offering is vital (Resei et al., 2019). Furthermore, there seems to be no mutual understanding regarding micro-credential offerings among stakeholders (Ahmat et al., 2021).

For example, Higher Education Institutions HEIs perceive micro-credentials as informal and formal short courses to recognise credentials. In contrast, learners perceive micro-credentials as the alternative way to acquire competency-based learning, but employers perceive micro-credentials as certificates of attending professional development (Ahmat et al., 2021). Fishman et al. (2018) also stated that knowledge acquired through micro-credential is obtained through informal means. This could also be the reason why most employers are unsure which micro-credentials can be trusted (Oliver, 2019). In South Africa, most HEIs offer micro-credential courses in the form of post-graduate diplomas or advanced post-graduate certificates. But even though HEI providers offer micro-credential programs, it is unknown whether employers accept national or international digital credentialing (Ahmat et al., 2021). Therefore, it is essential to involve employers in developing micro-credentials to mitigate inconsistent value and for providers to fully understand what is required in the marketplace (Copenhaver & Pritchard, 2017; Gauthier, 2020).

Quality assurance

Quality assurance is another challenge when it comes to micro-credential adoption. Studies show a significant increase in micro-credential providers equally in variety and size (van der Hijden, 2019). Therefore, the reputation of those who offer these micro-credentials is important (Resei et al., 2019). Van der Hijden (2019) stated that the downfall of most new providers is that they over-emphasise their reputation. Therefore, quality assurance when developing digital credentials remains the question that needs to be addressed (Fishman et al., 2018; Resei et al., 2019). This can be achieved by considering an entity that can validate the evidence presented in a digital credential if it is credible or not (Fishman et al., 2018). Furthermore, the guidance about credit allocation within the digital credential should be clearly stated, not just the qualification (Oliver, 2019).

Transferability and stacking

Initially, micro-credentials were designed to be stand-alone learning to meet scarce skill requirements (Fisher & Leder, 2022). They were designed to be stackable and transferable (Gibson et al., 2015; Liyanagunawardena et al., 2017; Oliver, 2019; Rossiter & Tynan, 2019). This means that one provider should recognise micro-credentials completed by another provider (Resei et al., 2019). However, some micro-credentials cannot be combined and stacked into a complete degree (Resei et al., 2019). Therefore, even though stacking

credentials can be an alternative way for a user to earn a degree gradually, some cannot be transferrable (Oliver, 2019; Resei et al., 2019). Hence, employees must understand that digital credentials can be formal or non-formal. Table 2 illustrates different types of credentialing.

Table 2 Different types of credentialing

Credentials	Definition	Example
Formal	Formal learning course	-Professional certificates -Degrees Micro-credentials
Non-Formal	Non-formal learning courses can be an addition or alternative to a formal course.	-MOOC certificates
Recognition of skills	Certificate of recognition for achieving a particular skill after an assessment	-Certificate of technical expertise -Certificate of skill update -Micro-credentials (Digital badges)
Record of experience	Certificates for completion of experience	-Certificate of Participation -Certificate of long-term service

Therefore, as shown in Table 2, micro-credentials are aligned to formal and skills recognition types of credentialing. By design, they should be transferable and stackable to promote lifelong learning (Weise, 2020).

Discussion

Most studies identified that the lack of micro-credential definition is the underlying cause of the challenges of their adoption in the workplace. Rimland and Raish (2019) shared the concept of micro-credential as virtual, portable learning of skills acquired granularly. This concept of micro-credentials as the virtual representation of skills was also applicable to the definition of digital badges by Borrás-Gené (2018), who identified digital badges as a clickable graphic that contains an online record of achievement and information about the organisation or entity that issued the badge. Therefore, the concept of micro-credential as a virtual representation of skills influenced various studies to adopt the terms 'micro-credential' and 'digital badge' to be used interchangeably.

The other narrative was defined by Kilsby & Fountain (2019), the concept of micro-credentials as competency-based professional learning to recognise a learners' skills and achievements. The competency-based concept was supported by other studies that demarcated micro-credentials as meta-skills, competencies, or accomplishments achieved by learners from micro-credentials providers (Ghasia et al., 2019). This concept highlights competency-based learning to achieve skills set as the focal point of micro-credential definition.

The other concept explored in this study was that of Lim et al. (2018), who expressed micro-credentials as mini-certifications in specific areas of study or professional development that will help recognise the student's skills. This concept of micro-credentials as mini certificates encompasses various forms of certification, including micro-masters,

nano degrees, and licenses, as long as the certification focuses on a small volume of learning and allows the learner to complete the certificate over a short period (Ahmat et al., 2021).

Therefore, all three concepts impaired from micro-credential definitions when compared to the traditional HEI system can be represented in the following concepts:

- *Micro-credential as a virtual clickable graphic*
Compared to the traditional university setting, this definition can be represented by a tangible certificate earned by a learner after completing the course.
- *Micro-credential as competency-based learning*
This definition in the traditional university setting can be represented by *credits* offered to the course to measure learning outcomes.
- *Micro-credential as a mini certificate*
This definition in the traditional university setting can be represented by a short course taken to achieve a particular set of skills.

Therefore, a clear definition is required to unify the abovementioned concepts and other concepts identified when defining micro-credentials. Galindo (2023) proposed micro-credentials (*credits*) + digital badges (*certificates*) = open badges (*digital credentials*) (Galindo, 2023). However, this is beyond the scope of this study.

Recommendations for adopting micro-credentials

Recognition mechanism

Orman et al. (2023) suggested that research on employers' appreciation and recognition of micro-credentials should be studied. Therefore, stakeholders involved in the micro-credential ecosystem must create a recognised framework to set a standard to enhance these credentials' credibility. The framework could help to promote broader acceptance for HEI and employers (Nordin et al., 2022).

Enhanced quality assurance

Oliver (2022) stated that quality assurance is needed for micro-credential offerings. However, there seem to be mixed emotions about how quality assurance can be implemented since the lack of transparency in standards remains a problem (Halas, 2022; ROMERO-LLOP et al., 2022). Another concern is that micro-credentials can both be formal and non-formal. Therefore, the question of how quality assurance can be established for non-formal credentials remains unknown (Cirlan & Loukkola, 2020). This study agrees with Oliver (2022) that since accredited HEIs already occupy a mature quality assurance process, they should offer an endorsement of credentials to private providers. However, this could come across as imposing regulation on private providers (Oliver, 2022). Therefore, this study recommends that experts should be involved in designing and validating the micro-credential offering. This will ensure that providers offer programs that align with the needs of industries. Additionally, it will ensure that continuous improvement is maintained.

Promote transferability and stackability

Gallagher (2019) emphasises the importance of education and solving a specific problem in evaluating human capital. Therefore, Desmarchelier and Cary (2022) suggested that stacked micro-credentials should be recognised as credit. Meaning 'learners must achieve equivalent learning outcomes as they would if they had completed all units in the degree programme' (Desmarchelier & Cary, 2022, p.1). Therefore, this study recommends that HEIs should collaborate with employers to establish a mechanism to transfer earned credentials (*credit*) toward a formal degree. Allowing learners to stack micro-credentials and acquire a complete qualification over time.

Conclusion

This study aimed to investigate the challenges in adopting micro-credentials for skills development in the workplace. A literature review was conducted to define micro-credentials and how they differ from digital badges and MOOCs. Investigating the challenges of micro-credentials in the workplace, themes such as lack of recognition, quality assurance, transferability, and stacking emerged as some employers still need to be more open to their credibility. Organisations need to adopt micro-credentials to equip the workforce for skills development.

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Investigations into ChatGPT using first-level programming MCQs

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Abstract

Understanding the possibilities and implications of artificial intelligence (AI) tools for teaching and learning is essential for educators in this era of AI growth. In this study, multiple-choice questions (MCQs) that are relevant to first-level programming courses are analysed from the perspective of educators to determine the strengths and limitations of ChatGPT, a generative AI tool that has taken centre stage in recent months due to its incredible knowledge capabilities in numerous fields. This research aims to determine how well ChatGPT can respond to typical MCQs, how accurate its explanations are, how well it can identify the questions' Bloom's taxonomy level, and its capacity to generate questions of a similar nature. This study examines ChatGPT in an exploratory setting following a self-study methodology using forty first-level programming MCQs from the Canterbury QuestionBank. Guidelines for educators are developed based on the outcome of the investigations into ChatGPT for designing and formulating MCQs in first-level programming. The paper also offers insights for educators on general concerns related to the use of ChatGPT. This research aims to promote much-needed discussions about utilising ChatGPT and other AI tools for teaching and learning, specifically in programming courses.

Keywords: ChatGPT, first-level programming, multiple-choice questions (MCQs), Canterbury QuestionBank, programming assessment

Introduction

ChatGPT is a generative artificial intelligence (AI) language tool developed by OpenAI that was released for public use towards the end of 2022 (Open AI, 2022). The tool can produce relevant content at the user's request (Cooper, 2023; Open AI, 2022; Pavlik, 2023). ChatGPT displays proficiency in numerous areas. For example, it can design and debug computer programs, generate poems and essays on various topics (Open AI, 2022), and generate strategies for teaching and assessments (Cooper, 2023). A notable feature of this tool is its ability to generate well-written text in a conversational style (Cooper, 2023; Pavlik, 2023), which means that it can solicit the user's input and clarification when creating and editing content (Open AI, 2022).

ChatGPT has taken center stage due to its impressive knowledge capabilities since its release. After the first week of its release, this AI tool managed to attain 1 million users, and this number grew to 100 million after two months of release. Currently, the number of visits to the ChatGPT website exceeds 1.5 billion monthly since March 2023 (Ruby, 2023). Predictably, this AI tool has caused strong sentiment in different sectors, including education. It is assumed that numerous students are already using ChatGPT or other similar AI tools in their learning (Cooper, 2023).

Given that AI offers several opportunities to improve teaching and learning (Miao et al., 2021), it makes sense to find ways in which AI, especially existing tools, can be incorporated rather than ignoring or excluding them from teaching and learning (Celik, 2023; Cooper, 2023). Since AI is here to stay, it is crucial for educators to comprehend the potential and implications of AI tools for teaching and learning. In this study, we study ChatGPT in the context of computer science education to determine its strengths and limitations from the perspective of educators.

An applicable area of research in computer science education is the examination of tools for teaching and learning from the viewpoint of the educator (Hazzan et al., 2011). Similar to research studying ChatGPT in science education (Cooper, 2023) as well as journalism and media education (Pavlik, 2023), ChatGPT is investigated in this study as a tool to support teaching and learning in computer science education, specifically for first-level programming assessment. In particular, this study aims to determine (a) how well ChatGPT can respond to typical first-level programming multiple-choice questions (MCQs), (b) how accurate its explanations of those answers are, (c) to what extent it can identify the questions' Bloom's taxonomy level, and (d) its capacity to generate questions of a similar nature. Aspects (a) to (d) are investigated with the aim of helping educators comprehend how ChatGPT can be used in designing and formulating MCQs in first-level programming courses. This research is conducted as exploratory research following the self-study method (Cooper, 2023; Samaras, 2011). Forty first-level programming MCQs are taken from the Canterbury QuestionBank (Sanders et al., 2013), an open repository, and are used in this research for interacting with ChatGPT.

This paper is structured into nine sections. An introduction to this study is included in the section named *Introduction*. ChatGPT and the Canterbury QuestionBank are presented briefly in the section titled *Background*. The next section titled *Research Methodology* includes a discussion of the research methodology used in this research. The characteristics of the MCQs used for interacting with ChatGPT are described in detail in the section named *Dataset description*. The section named *ChatGPT setup* explains how ChatGPT was utilised in this study. The outcome of the interactions with ChatGPT is discussed in the section titled *Results*. A discussion on how ChatGPT can be used based on the content presented in the section *Results* is included in the next section named *Guidelines*. Other general aspects pertaining to the use of ChatGPT are included in the section *General aspects relating to the use of ChatGPT*. The section *Conclusion* concludes the paper.

Background

In this section, ChatGPT, the AI tool in focus, and the Canterbury QuestionBank from which the dataset is derived for this study are discussed briefly.

ChatGPT

ChatGPT is a language model that is trained using machine learning algorithms that utilises vast amounts of data (Cooper, 2023). This training process using such large amounts of data affords the language model the opportunity to learn about different aspects relating to multiple knowledge areas, which allows it to communicate in a human conversational style and generate content similar to that of a human expert (Cooper, 2023). This language model

is trained using reinforcement learning (Open AI, 2022), a machine learning method, and is capable of learning with time, making it a dynamic model. In other words, in principle, it has the ability to learn constantly and improve itself.

Since the release of ChatGPT in late 2022, users can interact with the tool for free. However, it also now offers a paid option for a better performing tool named ChatGPT Plus. There are two different ways in which you can interact with ChatGPT: one using the standard chat using prompts and another using the Application Programming Interface (API). Utilising APIs allows one to build applications that include the pre-trained language models from OpenAI (Open AI, 2022).

Canterbury QuestionBank

The Canterbury QuestionBank was designed and developed by the Canterbury working group, which consists of ten members, and made available on a website (<https://web-cat.org/questionbank/>) in 2013 (Lister et al., 2013). This repository is a collection of MCQs that covers first-level computer science topics. These topics include programming questions in different languages and theoretical and data structures questions (Sanders et al., 2013). This open repository has well over 600 MCQs, and educators can also contribute questions to the repository (Lister et al., 2013). It was developed with the aim of providing computing educators with an in-depth set of questions that they can reuse in their courses and facilitate research (Sanders et al., 2013).

Each entry in the Canterbury QuestionBank has a unique identification number, a question, answer options, the correct answer, and an explanation of the answer to the question. Each question also has a set of optional metadata that contains information such as the name of the contributor, programming language if relevant, topic, difficulty of the question, Bloom's taxonomy level, and conceptual and linguistic complexity (Sanders et al., 2013). Not all questions have all the relevant metadata, as it is up to the contributors to create relevant metadata (Lister et al., 2013).

Research methodology

This study uses explorative research to examine ChatGPT. This explorative research follows the self-study method. The self-study method originates from the field of education and is primarily used by educators to understand and improve teaching and learning in a classroom. However, the method has been used by specialists to examine aspects outside a classroom setting (Cooper, 2023; Samaras, 2011).

The self-study approach is built around five guiding principles. First, it is a method for learning from one's own experiences related to an area of interest. Second, it seeks to further knowledge of the subject matter in a setting where the researcher is also a practitioner. Thirdly, it promotes an organised and transparent approach to researching the subject of interest. Fourthly, it seeks to provide knowledge that other educators can use. Fifth, the research must permit input from other instructors. When an educator uses the self-study method in a teaching context, they work to better understand a topic that interests them for their own professional growth and practice and to impart their new knowledge to other educators (Samaras, 2011).

The self-study guiding principles were followed in this research. The researcher has been a programming educator for well over fifteen years and has taught programming at all undergraduate levels. Given the proliferation of AI tools and the general hype around ChatGPT, the researcher was interested in examining how ChatGPT can be utilised in programming instruction from the point of view of educators. Although there is anecdotal evidence of the remarkable capabilities of ChatGPT, very little is available in the literature on how it can be used in programming instruction. This research was, therefore, designed to examine ChatGPT as a potential teaching tool and the possible implications of using such a tool. The results of the investigation will be presented for publication and at conferences, and the feedback from reviewers and other educators will be used to consolidate the recommendations of the investigation.

Dataset description

The first forty programming MCQs were selected from the Canterbury QuestionBank for this study. This set of forty MCQs will be referred to as the dataset from this point on. As this research is qualitative in nature with the end goal of developing recommendations for programming educators using ChatGPT, it seemed sufficient to utilise forty MCQs from the repository. Moreover, these forty questions were varied in terms of the programming language used, Bloom's taxonomy level, difficulty as perceived by an average learner, associated skills, topics covered and the presentation style.

In the dataset, the number of alternatives (answer options) was either two, three, four, or five. The majority of the MCQs had five alternatives, while only one question had two and three alternatives each. Irrespective of the number of alternatives, all the MCQs in the dataset had only one alternative marked as the answer.

The programming languages used in the dataset are Java, C and Python. There are three main ways in which the programming language of a question can be identified. The programming language is inferred from the code included or specified as part of the question. There is also optional metadata that contributors to the repository provide for each question. One of the metadata is the programming language used. Only four out of the forty selected MCQs did not have the programming language specified in the metadata. For those four questions, the researcher could identify the programming language based on the contents of the questions. Figure 1 (a) includes a pie chart that shows the number of questions that used Java, C, and Python. As depicted in the figure, Java is the most frequently used programming language, followed by C and Python. There is also a question in the dataset that does not include any programming language, as it was meant to be relevant to any programming language.

The dataset also includes the difficulty of the MCQ as an optional item of metadata. *Low*, *medium*, and *difficult* are the values for the difficulty level. The contributor of the MCQ created this metadata, which is based on their experiences as seen through the eyes of typical students. The dataset includes eight questions without difficulty metadata and thirty-two questions with difficulty metadata. There are two questions in the *difficult* category and fifteen each in the *low* and *medium* difficulty categories out of the thirty-two questions.

Figure 1 (b) includes a pie chart that shows the number of questions at the different difficulty levels.

Another item of metadata included in the repository is the Bloom’s taxonomy level of an MCQ. Possible values for Bloom’s levels are *knowledge*, *comprehension*, *application*, *analysis*, *synthesis*, and *evaluation* (Sanders et al., 2013). Again, this metadata is generated by the MCQ contributor. The dataset includes thirty questions, with Bloom’s taxonomy levels included. Out of the thirty questions, there are five questions in the *knowledge* category, seven questions in the *comprehension* category, two questions in the *application* category, eleven questions in the *analysis* category, and five questions in the *synthesis* category. There were no questions in Bloom’s classification level *evaluation* in the dataset. Moreover, ten MCQs did not have their Bloom’s taxonomy level indicated in the dataset. Figure 2 (a) includes a pie chart that shows the number of questions at different Bloom’s taxonomy levels.

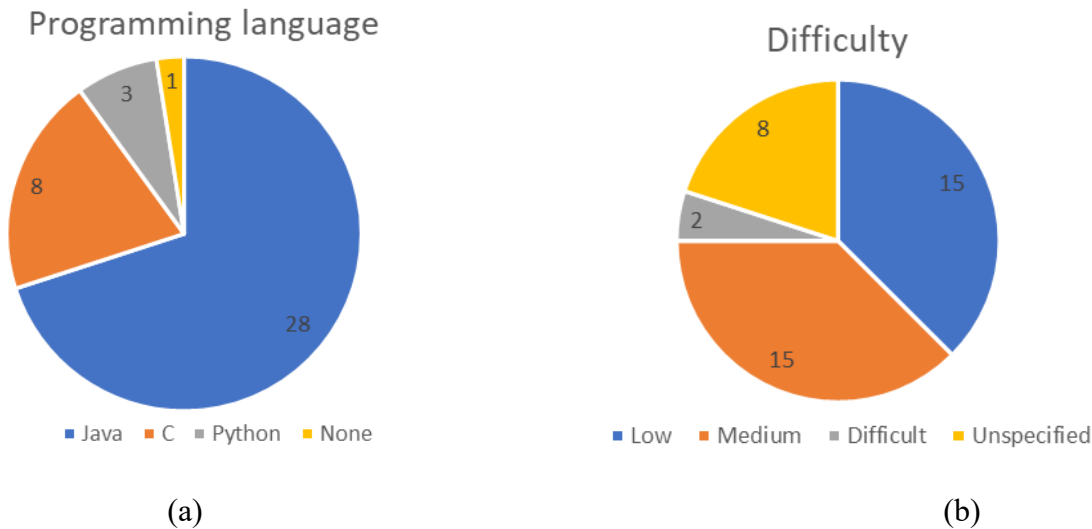


Figure 1- (a) The pie chart shows that the majority of MCQs used Java, followed by C and Python. One MCQ did not use any programming language, as it was meant to be a general question relevant to any programming language. (b) The pie chart shows that there were an equal number of questions in the difficulty categories of low and medium. There were eight questions without difficulty classifications and two questions were classified as difficult.

Figure 2 (b) includes a pie chart that depicts the number of questions that included and did not include graphical elements in the stem of the MCQ. Only three questions in the dataset included some form of graphical element in the stem. Out of the three questions, two included Unified Modeling Language (UML) class diagrams, and one included an image. The majority of the questions in the dataset used only text, including code.

The dataset also included a variety of question types, which were specified by the MCQ contributor in the metadata. The dataset had eight distinct question categories, which are

presented in Table 1. In the dataset, the question types of twenty-nine questions are specified, but not for the other eleven questions as metadata entries are optional in the repository. Questions that expected students to write and trace code were most frequently used in the dataset. In an MCQ context, writing code translates to choosing code that meets certain criteria specified in the question.

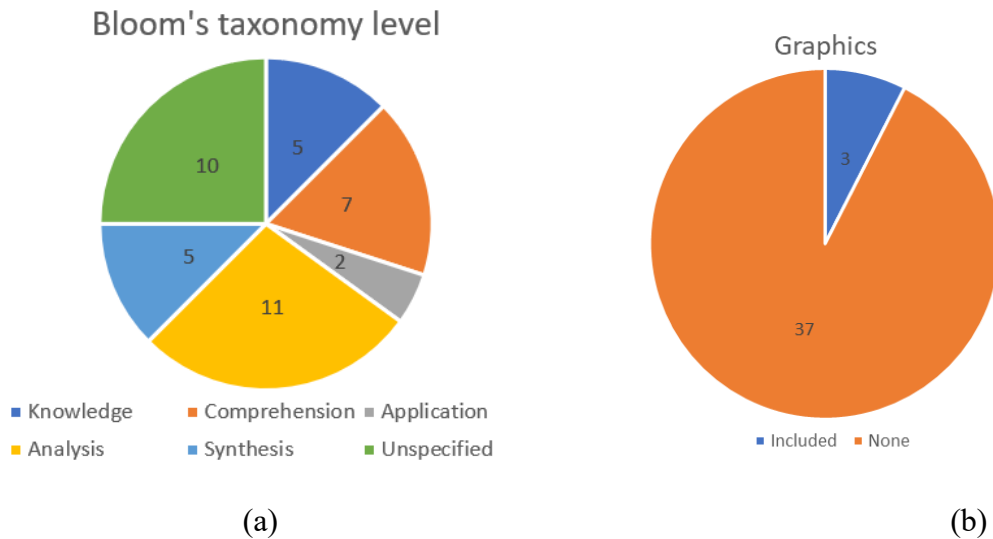


Figure 2- (a) The pie chart shows the number of MCQs at different Bloom’s taxonomy levels in the dataset. (b) The pie chart shows that only three MCQs in the dataset used graphical elements in the stem of the questions, while thirty-seven included only text (including code) in the question.

Table 2: The list of question types and number of questions in each type in the dataset

Question type	Number of questions	Additional notes
Write code	8	In the context of MCQs, it will be choosing the correct code. It also includes rewriting code.
Trace code	9	It includes expressions
Analyse code	2	It includes writing pre-conditions
Design code	3	It focuses on the design and not on the implementation
Debug code	4	It focuses on identifying and/or explaining errors
Theoretical knowledge	1	It focuses on theoretical knowledge of a programming language
Test code	1	It focuses on aspects relating to testing code
Explain code	1	It focuses on explaining some aspect of the given code

The programming topics used in the dataset were also varied. These topics included variables, datatypes, assignment, scoping rules, methods, functions, operators, loops, recursion, memory management, strings, overloading, pointers, arrays, and object orientation. Most MCQs used multiple topics because it is often the case that computer programs make use of multiple concepts to encode the desired logic.

Code lengths for the questions that did include them ranged from one to six or from six to twenty-four lines. The line numbers were indicated in various ways in different questions when a question contained a code fragment and the code line numbers were relevant to the question. In the dataset, line numbers were encoded in two different ways. One was to prefix the code with the line number. For example, in this format the first line of code will start with 1:. The second method involved placing line numbers after each line of code as comments. For instance, the second format would append //line 1 at the end of the first line of code. Most questions that used the second method did not use comments to identify every line of code. So, it was plausible that when a question mentioned line 2, it wasn't referring to the second line of code but rather to the line that had the comment line 2.

ChatGPT setup

In this study, the free version of ChatGPT, GPT-3, was utilised using its chat prompt. All interactions with ChatGPT for this study were performed over a period of two months (June and July) in 2023. Interactions were once-off in the sense that no attempt was made to repeat interactions with the same content to ascertain whether the responses had changed. Given that ChatGPT is capable of learning and improving itself, the researcher assumes that its responses to the same requests may be different, possibly better, at a later stage. When interacting with ChatGPT, no explicit feedback was provided to improve its AI model.

When interacting with ChatGPT, a specific sequence of prompts was used for each MCQ in the dataset. The stem (question) and the alternatives (possible answers) were provided on the first prompt. The following request was to explain the answer if the response from ChatGPT contained merely the answer. If the answer to the MCQ was provided along with an explanation, the next prompt asked for the question's Bloom's taxonomy level. The final prompt was to offer a variation of the given MCQ.

Results

The outcome of the interactions with ChatGPT is presented in this section. The results of the interactions are presented in four sections: answers to the MCQs, explanations of the provided answers, identified Bloom's taxonomy levels, and variations of the provided questions.

Answers to the MCQs

All the questions (stems and alternatives) in the dataset were copied and pasted into the ChatGPT prompt except for those three questions with graphics. During the specified period of interaction, ChatGPT did not accept any diagrams. Out of the three questions with diagrams, one diagram was translated in brief and the two other questions were provided in the chat without diagrams. Translations of diagrams in these two questions were considered unnecessary because the diagrams provided auxiliary knowledge that was not strictly necessary for the questions to be answered.

The related answers from ChatGPT and the Canterbury QuestionBank were compared. If the response provided by ChatGPT matched the answer exactly in the repository, the response was classified as *correct*. On the other hand, if an answer provided by ChatGPT differs from the response provided for that MCQ in the repository, the answer was classified

as *incorrect*. ChatGPT provided *correct* answers for twenty-nine out of forty MCQs in the dataset. In other words, 72.5% of the answers were correct and 27.5% of the answers were incorrect. Figure 3 (a) depicts a pie chart with the number of correct and incorrect answers provided by ChatGPT.

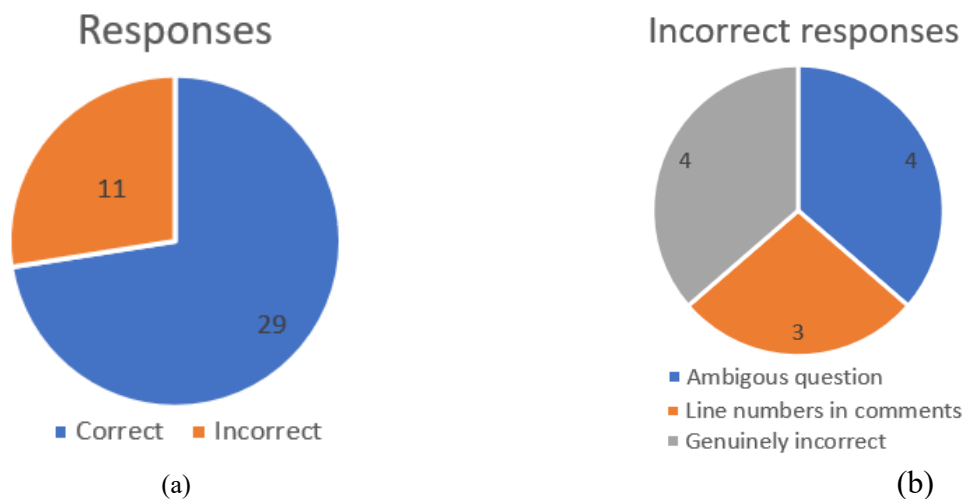


Figure 3- (a) The pie chart shows that ChatGPT answered twenty-nine MCQs correctly and eleven incorrectly. (b) Out of the eleven MCQs that were answered incorrectly, four were ambiguous, three had code line numbers in comments that did not match the actual code line numbers and the other four MCQs had no obvious problems.

Four questions were ambiguous in the sense that more than one option may be deemed correct, according to further investigation of the eleven MCQs that ChatGPT erroneously answered. In other words, distractors of these MCQs were not carefully designed. Three other MCQs in the set of eleven questions were incorrectly answered because the line numbers indicated in the question referred to the line numbers in the comments as opposed to the actual line numbers in the code. Answers to the last four MCQs can be genuinely considered incorrect. The content of these MCQs included pointing out a bug as per the question while there was no bug in the given Java code fragment, identifying objects and references in Java, and identifying boundary values used in testing. Figure 3 (b) summarises the above-discussed aspects in a pie chart.

No effect was found in the number of alternatives in a question, programming language used, difficulty of the question, Bloom’s taxonomy level of the question, inclusion of graphical elements, or type of question in the answers (refer to the Section titled *Dataset description*) provided by ChatGPT.

Explanations of the provided answers

All the explanations provided by ChatGPT were analysed for correctness by comparing them to the explanations included in the QuestionBank. In general, explanations provided by ChatGPT are more verbose than those included in the QuestionBank. Therefore, deciding the correctness of the explanations was more time-consuming than, for example, deciding

whether the generated answers were correct. For each question, the explanation provided by ChatGPT was analysed to see whether it was correct based on the explanations in the QuestionBank together with the researcher's programming knowledge.

The outcome of the analysis for the correctness of an explanation was marked *correct*, *incorrect*, or *partially correct*. An explanation was marked *correct* when it contained accurate information on why the selected option was the answer. An explanation was marked *incorrect* when the given explanation was inaccurate. On the other hand, an explanation was marked *partially correct* when it contained some accurate and some inaccurate information, making it partially accurate. In other words, a *correct* explanation could be used as it is, an *incorrect* explanation could not be used at all, and a *partially correct* explanation could be used with some modification if it had to be used in a real-life teaching and learning context, for example, to provide feedback on a student's attempt. No importance was given to the length of the explanation.

As depicted in Figure 4, out of the forty questions, the explanations to thirty-five questions were found to be *correct*. For the remaining five questions, explanations for three questions were found to be *incorrect*, and explanations for two questions were found to be *partially correct*. The following is the analysis of explanations as per correctly and incorrectly answered questions (refer to Figures 3(a) and 3(b)):

- Out of the twenty-nine questions that were correctly answered by ChatGPT (see Figure 3 (a)), explanations to all but one question were *correct*. This question that resulted in an *incorrect* explanation did make use of code that contained comments as line numbers (refer to the Section titled *Dataset description*). Also, for this question, an explicit prompt had to be made to obtain an explanation because a description of the answer was not provided with the initial prompt of requesting the answer. When requested for an explanation, an *incorrect* answer along with an *incorrect* explanation was provided.
- Out of the four questions that were *incorrectly* answered due to ambiguity (see Figure 3 (b)), the explanations to the provided answers were *correct*. However, ChatGPT did not explicitly indicate in the explanations or in the answers that there are multiple answers possible for these questions.
- Out of the three questions that were answered *incorrectly* due to having line numbers indicated as comments, two of the explanations were *correct*. In these two cases, the explanations contained lines of code instead of line numbers.
- Out of the four questions that were answered *incorrectly* and marked as genuinely incorrect, two of the explanations were *partially correct* and one was *incorrect*. Interestingly, for the last (fourth) question in this category, it was found that the explanation included the *correct* answer, but an *incorrect* answer was indicated as the answer when requested in the first prompt. In other words, the explanation and the indicated answer did not match for this question.

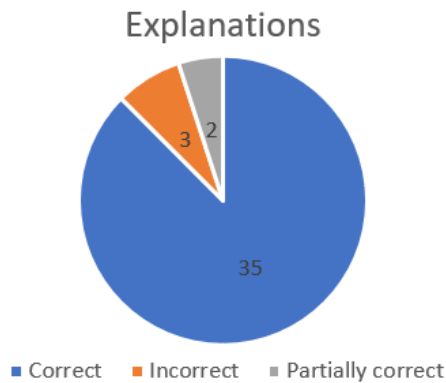


Figure 4- The pie chart shows that ChatGPT provided correct explanations for the generated answers for most of the questions (87.5%). Only 7.5% and 5% of the explanations were incorrect and partially correct respectively.

Identification of Bloom’s taxonomy levels

The Bloom’s taxonomy level of each question in the dataset was requested from ChatGPT. The taxonomy levels indicated by ChatGPT were then compared to those of the metadata included in the Canterbury QuestionBank. If the response provided by ChatGPT matched the Bloom’s taxonomy level mentioned in the repository, the response was marked as *correct*. On the other hand, if a Bloom’s taxonomy level indicated by ChatGPT differs from the response provided for that question in the repository, the response is marked as *incorrect*.

Out of the thirty questions that have Bloom’s taxonomy level specified in the dataset (refer to Figure 2 (a)), only taxonomy levels of seven MCQs were identified *correctly* by ChatGPT. In other words, ChatGPT gave *incorrect* taxonomy levels for over 80% of the questions. Out of the seven questions that were *correctly* identified, three had taxonomy-level *knowledge*, and two each had taxonomy-level *comprehension* and *analysis*. Figure 4 depicts the number of taxonomy levels *correctly* and *incorrectly* identified by ChatGPT.

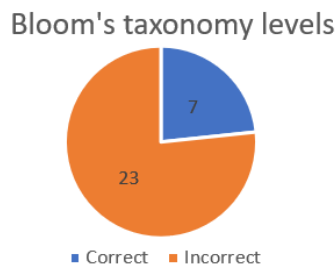


Figure 5- The pie chart shows that out of the thirty MCQs that had Bloom’s taxonomy levels specified as metadata, ChatGPT only identified the Bloom’s taxonomy levels of seven MCQs correctly while it could not give the correct taxonomy levels of the other twenty-three MCQs.

Unlike the answers and the explanations of the answers, the researcher did not feel knowledgeable enough to assess the Bloom's taxonomy levels included in the metadata for correctness. Programming educators, in general, find it difficult to establish the correct Bloom's taxonomy levels of programming questions (Masapanta-Carrión & Velázquez-Iturbide, 2019). This difficulty can lead to the possible identification of different Bloom's taxonomy levels for the same question by different educators (Sanders et al., 2013). Training interventions are often implemented for programming educators to overcome this difficulty (Masapanta-Carrión & Velázquez-Iturbide, 2019; Sanders et al., 2013). There can be significant subjectivity when identifying Bloom's taxonomy level for a programming question, which is in contrast to establishing programming proficiency. The results of the identification of Bloom's taxonomy levels by ChatGPT, therefore, may be slightly better than what is presented in the paper. However, the presented programming knowledge is significantly better than Bloom's taxonomy knowledge of ChatGPT.

Variations of the MCQs

All the variations of MCQs provided by ChatGPT were analysed for correctness. The variations were analysed by comparing them to the original question in the question bank. The outcome of the analysis for the correctness of a variation was marked *acceptable*, *unacceptable*, or *acceptable after modification*. A variation was marked *acceptable* if the question and answers can be used as they are because there are no errors in them and it is a valid variation, meaning that it is different from but contains the core theme of the original question. If the generated question is not a genuine variation or has errors that cannot be easily rectified without a significant modification of the MCQ, the variation is marked as *unacceptable*. A variation was marked *acceptable after modification* if it is a valid variation, but it needs some minor modifications.

As depicted in Figure 6, the majority of the variations (65%) were *acceptable*, 25% of variations needed some minor modifications (*acceptable after modification*) and a minority of variations (10%) were not usable (*unacceptable*). Three out of the four variations that were in the category of *unacceptable* were exactly the same original MCQ and the fourth variation was an incorrect question that could not be easily rectified. The minor modifications required for the questions in the category of *acceptable after modification* included reformatting the variation as an MCQ, rephrasing variations to make them clear, updating certain phrases and code line numbers. It is worth noting that for those four MCQs (indicated as genuinely incorrect in Figure 3 (b)) that ChatGPT did not provide *correct* answers for, none of their variations were in the category of *unacceptable*. In other words, ChatGPT could generate satisfactory variations of MCQs even though it could not answer them correctly.

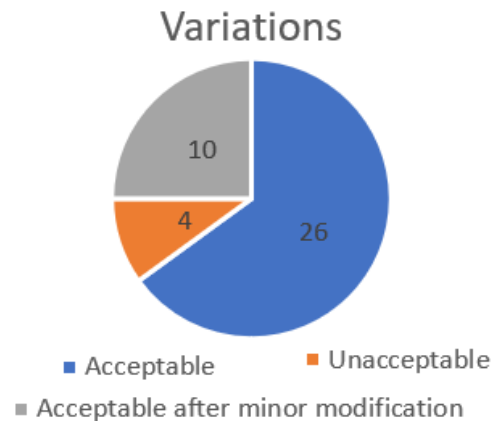


Figure 6- The pie chart shows the number of variations of MCQs generated by ChatGPT that were in the categories acceptable, unacceptable and acceptable after minor modification. As shown in the diagram, twenty-six, four and ten variations of MCQs generated by ChatGPT were in the categories of acceptable, unacceptable and acceptable after modification, respectively.

No effect was found in the number of alternatives in a question, programming language used, difficulty of the question, Bloom’s taxonomy level of the question, inclusion of graphical elements, or type of question in the variations (refer to the Section titled *Dataset description*) provided by ChatGPT.

Guidelines

Based on the results included in the Section titled *Results*, the following main aspects can be concluded:

- ChatGPT can demonstrate a high standard of programming knowledge across multiple programming topics and languages.
- ChatGPT can generate detailed explanations of programming concepts.
- ChatGPT does not demonstrate a good understanding of Bloom’s taxonomy level of programming MCQs.
- ChatGPT can generate acceptable variations of programming MCQs.

Using the results included in the Section titled *Results*, a few guidelines for utilising ChatGPT for designing and formulating MCQs in first-level programming are developed. These guidelines are as follows:

1. ChatGPT can be used to verify MCQs, especially for correctness and ambiguity.
2. Diagrammatic representations in an MCQ must be translated to text before they can be accessed by ChatGPT.
3. If ChatGPT provides an answer to an MCQ correctly, then the explanation generated by it is most likely to be correct and can be used for teaching and learning purposes.
4. If ChatGPT provides an incorrect answer to an MCQ, use the generated explanation to analyse the correctness of the MCQ.

5. Even though ChatGPT is capable of generating lengthy and well-written explanations, it can still generate inaccurate and contradictory explanations.
6. If the question has code fragments with comments indicating line numbers, there is a high probability that ChatGPT will not read the line numbers correctly, resulting in incorrect answers and explanations. One can address this issue to a certain extent by indicating in the stem of the MCQ that the line numbers are indicated as comments in the code.
7. In its current state, ChatGPT cannot be reliably used to identify or verify Bloom's taxonomy levels for MCQs.
8. ChatGPT can be used to reliably generate variations of MCQs.
9. Since ChatGPT accesses textual summaries of diagrammatic representations in an MCQ, the variations of MCQs generated by ChatGPT will not have diagrams.
10. If an MCQ has code fragments with comments indicating line numbers, there is a high probability that ChatGPT will not read the line numbers correctly, resulting in variations in the MCQ that require some modifications.
11. Even if ChatGPT cannot answer an MCQ correctly, it can still be used to generate acceptable variations of the MCQ.
12. ChatGPT can be used for MCQs relating to multiple programming languages.

In general, the proficiency and knowledge presented by ChatGPT on first-level programming content and languages are remarkable. However, it is necessary for academics to provide oversight over the content generated by ChatGPT. If an educator designs an MCQ, ChatGPT can be used to moderate the MCQ. On the other hand, if ChatGPT generates an MCQ, then the educator must play the role of the moderator. For all the aspects, except for identifying Bloom's taxonomy levels, investigated in this paper, ChatGPT can be utilised for the formulation MCQs.

General aspects relating to the use of ChatGPT

There are a few general aspects that educators need to be aware of when utilising ChatGPT for teaching and learning. Firstly, large machine learning models in general are resource-intensive, specifically using large computational power, which has direct implications for power usage. Increased power usage can result in an increased carbon footprint. Secondly, by default, ChatGPT does not indicate the resources that were consulted in generating text. There are repercussions from this lack of transparency, one of which is whether ChatGPT is violating any copyrights. If an educator uses content generated by ChatGPT, they can possibly be violating some copyrights. Thirdly, following from the second point, if an educator is giving ChatGPT access to some copyrighted material, they should be aware the material may be used by ChatGPT without regarding the copyright on the material (Cooper, 2023).

Conclusion

In this research, ChatGPT was explored for its use as a possible tool in an educator's toolbox. Specifically, this study assessed responses of ChatGPT to first-level programming multiple-choice questions (MCQs), the accuracy of the generated explanations, its capacity to determine the questions' Bloom's taxonomy level, and its capacity to generate questions with a similar content and structure. By following a self-learning methodology, this study used

forty first-level programming MCQs from the Canterbury QuestionBank in an exploratory setting to understand the strengths and limitations of ChatGPT. Based on the findings of the interactions with ChatGPT, guidelines for educators are created on how to utilise it in the design and formulation of MCQs for first-level programming. The paper also provides guidance for educators on other issues surrounding the usage of ChatGPT.

In summary, this research found that ChatGPT can be a valuable tool in an educator's toolbox. However, there are limitations to ChatGPT that educators' need to be aware of, which necessitates oversight by educators over the content generated by ChatGPT. Moreover, educators need to be cognisant of the possible increase in carbon footprint and copyright infringements when using ChatGPT.

In this era of AI growth, educators will be faced with numerous AI tools. There might be possibilities and opportunities in these AI tools that need to be explored in a meaningful way for educators and students alike. This study contributed to the understanding of how one specific AI tool can be used in the formulation of questions in a specific subject. It is hoped that this study will inspire educators to explore different ways of utilising AI tools in their teaching and share their findings with the relevant community of educators.

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Digital divide: A threat to digitalization of teaching-learning process for students with disabilities in Nigerian Universities

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Abstract

Unfortunately, persons with disabilities in Nigeria are trapped by digital-divide related challenges originating from institutional to personal barriers which threaten unhindered access to quality education. Resultantly, this study investigated the digital technology gap in the Nigerian universities with the focus of ascertaining the level of digital technology integration into the teaching-learning process for students with disabilities in Nigerian Universities. The study adopted a descriptive survey design. A purposive sampling technique was used to select 750 respondents comprising of 250 students with disabilities, 250 students without disabilities and 250 university teachers from 12 universities. A sectionalized instrument titled Digital Divide and Integration (DDI) pilot tested with reliability coefficients ranging from 0.83 to 0.89 internal consistency was administered. Four research questions guided the study and one hypothesis was tested at 0.05 level of significance. The data collected were analyzed descriptively using charts and percentages while the hypothesis was analyzed using one-way ANOVA. The result showed that the sociodemographic disparity in digital access between students with disabilities and those without is unreasonably wide. Also, the level of digital technology integration into the university teaching-learning process for persons with disabilities is too low indicative of exclusion. Bridges identified included strong political will, integrated funding approach, and School ICT support for students and teachers among others. It was also revealed that there was no significant difference in the utilization of digital technology among students with high-incidence disabilities. Suggesting that no group is significantly supported in terms of building digital capacities for the digitalization of the learning process in the university. Recommendations were made amongst others that universities in Nigeria should step up digital technology culture through diverse programmes and engagements with relevant stakeholders to deepen utilization and bridge the divide for students with disabilities.

Keywords: Digital divide, teaching-learning process, students with disabilities

Introduction

Digitalization of education services and information processes in schools represents a cornerstone of innovative, creative and dynamic classrooms. The proportion of digital tools and digitally shared information is gradually increasing. The use of modern technologies in

educational processes also increases requirements for technical support in line with digital accessibility requirements. These new tools may represent threats as well as opportunities for securing equal access to education and information for promoting equal opportunities for PWDs (Regec & Regec, 216:53-68).

Digitalization of teaching-learning can simply be conceptualized as the use of digital devices and channels to deliver instructional content to learners who may not have physical contact. It is the transformation of the pedagogical process from the use of printed materials to a soft version of resources through various devices and online platforms. Williamson, Eynon and Potter (2020) refer to it as digital education formats which rely on tech-devices to promote the trend of remote forms of teaching and learning. This requires the use of high and low tech-devices that can access, store, and use e-resources from various sources in the classroom as well sharing the same to other in a mass scale. Digitalizing of teaching and learning process has enormous implications on the government, teachers, learners and other stakeholders in education. As simple and necessary as Smartboards, projectors, wireless internet services, computers or laptops etc, may appear to be most schools, homes, learners cannot have access to these and other devices. To be active in a digitalized learning environment, learners must acquire beyond the devices, skills, literacy and attitude required for digital learning. while this may be seamless for learners without disabilities, the majority of those with disabilities may find it difficult and challenging to adjust to the new normal. Uğur (2020) confirmed that using digital devices in the classroom can create a level of ease and comfort for learners but most of students' experiences in using digital tools make it difficult for them to fit into the digital age classroom.

The International Telecommunication Union (ITU) reports that the complex nature of business in modern society and labour market forces, have led to an unprecedented expansion of the adoption of Information and Communication Technologies (ICTs), including in the developing world. Consequently, the world recorded over 5 billion mobile devices users, over 1.2 billion fixed telephone lines, and some two billion Internet users. In addition, virtually all areas are covered by broadcasting services. Despite these successes, over 650,000,000 persons living with disabilities are at risk of being excluded from essential services, social interaction and information sources delivered through ICTs. The policy on accessibility was launched intentionally to further deepens the need for all products and services to be reachable by all categories of citizens however, PWDs as the most vulnerable in the society are affected by the forces or issues that limit their opportunity to fully access and use technology and the products. This further divides the society beyond ability and disability lines to digital ability measured by the capacity of PWDs to access, own and use digital devices. This inability results to a phenomenal issue called a digital divide.

The concept of digital divide has become a common household word and it is as broad as technology and the world itself. The availability of technology and its enabling environment is not an equitable distributed service and product. A myriad of challenges, such as poor socioeconomic backgrounds and financial constraints, contribute to the academic performance of students with disabilities. Additionally, the shift to online or digital learning has presented an array of uncertainties (Fernando & Botelho, 2021). In Nigeria, despite the existence of policies that were formulated to address the educational inequalities, students

with special needs are still experiencing socioeconomic, academic and financial challenges to meet the demands of digital age and completing their training programmes to become active and useful to self and society.

Nigeria has a robust educational system with university education as the peak and pride of average Nigerian as evidence of having gone to school. The mandate of this level of education is to produce high level manpower to meet the socio-economic, political and technological needs of the nation. Digital technologies are pervasive in our professional and personal lives and over the last two decades higher education has used tech-tools in teaching and learning. This is because of the nature of university education, how it is delivered, the dynamics of the emerging society and the role of universities in society and the economy are changing and will continue to change significantly in the coming decade. In era where universities compete for students, academics and funding all over the world, it's only those that stay relevant and leverage new digital capabilities will benefit in this digital age (Hillman, Bergviken & Ivarsson (2020). The education system is seemingly growing to a level where nobody can learn meaningfully and conveniently without digital technologies.

This study highlighted these challenges to include but not limited to the users' digital literacy skills, digital age, cost of tech-devices, school locations, internet connectivity, disability profile, power availability. In a related study, Idris and Adaka (2023) identified poverty as part of dividing force that exclude persons with disabilities from accessing digital and economic equality like their peers without disability. Statistically, the study revealed that 20 million of 206.1 million lived with various disenabling conditions characterized by unproductive lives and are classified as the poorest of the poor trapped by the vicious cycle of poverty. It concludes that its quite unfortunate that persons with disabilities in Nigeria like in most developing countries are improvised, marginalized and overtly denied access to public health, education and other social services. Digital skills are central to human participation in socio-economic, educational and vocational development, to stay relevant acquisition of relevant skills and competence are core to human activities. Asiru and Namani (2023) opined that digital skills are important as social skills are required for full inclusion and interaction as lack of it will result to glossophobia. Glossophobic children are unprepared for learning as it generally cannot take place without social interaction thus, digital skills are required to enhance cyber interaction and digital inclusion needed for participation in global affairs.

The objectives of National policy on special needs education summararily aims at total service delivery to PWDs irrespective of setting (home, school, hospital), development of PWDs at the pace commensurate to their abilities and to contribute to the nation's socio-economic and technological development and provide quality education to all persons with disabilities. These objectives cannot be achieved in the 21st century without basic ICT literacy. This implies that deliberate efforts should be made by relevant stakeholders to train PWDs on the digital skills required to manage instructional process in the digital age. This should be based on need assessment as a road map for the training.

Objective of the study

The was conceived to investigate the digital divide as a threat to the digitalization of teaching-learning process for students with disabilities in Nigerian Universities. It sought to answer the questions related to digital integration into the teaching-learning process in Nigerian Universities.

Research questions and hypothesis

A hypothesis and four research questions were formulated and framed to guide the study as seen below:

1. There is no significant difference in the utilization of digital technology among students with high incidence disabilities in the university.
2. What is the level of digital integration into the teaching-learning process in Nigerian Universities?
3. What is the competency level in the use of digital technology among students with disabilities in Nigerian Universities?
4. What challenges militates against digitalization of teaching-learning process in Nigerian Universities?
5. What strategies will close the digital-divide for students with disabilities in Nigerian Universities?

Statement of problem

Education is seen as the best legacy a nation can provide and leave for generations, policy and legislative frameworks enforce it as a fundamental human right for all citizens inclusive of those with disabilities. In Nigeria, it is adopted as a tool par excellence for individual and national development. The 21st century educational system has experienced phenomenal shift as response to technological advancement and the realities of the digital age. The right of PWDs to access quality education is seemingly denied at best restricted due to lack or inadequate ICT skills required for active participation in the digital teaching-learning process which characterizes modern education space. The shift to online or digital learning has presented an array of uncertainties and challenges to persons with disabilities in pursuit of their educational career for self-advancement.

This problem is attributed to socio-economic factors, cost of tech-devices, school location, availability of electricity, disability, internet connectivity, lack of knowledge of digital devices, low self-esteem, low resilience level, learned helplessness, and lack of training on digital skills among others. These digital-divide-related challenges further deepen and extend the gap between persons with and without disabilities to the acquisition of digital skills, constituting a threat to digitalization of instructional delivery, attainment of programme goals, self-actualization and rip off the contributions of PWDs to the socio-economic, political and technological development of the nation.

Methodology

The study adopted a survey method by employing a questionnaire to gather data. The survey instrument for this study consisted of a self-administered questionnaire. The 35-item sectionalized questionnaire was designed to capture digital divide and integration of digital technology into the university teaching-learning process. A Descriptive survey method of chats was adopted to analyzed the 4 research questions. This study was conducted on 750

respondents comprising of university teachers, university students with and without disabilities from 12 universities across 3 Geopolitical Zones in Nigeria. 4 universities were randomly sampled from each randomly sampled Geopolitical Zone. 62 or 63 respondents were sampled from each university. A one-way ANOVA was performed to test the hypothesis using Statistical Package for Social Sciences (SPSS). The reliability of the instrument was established with internal consistency method which yielded reliability coefficients that range from of 0.83 to 0.89.

Results

H₀ 1: There is no significant difference in the utilization of digital technology among students with high incidence disabilities in the university

Table 1: summary of difference in the utilization of digital technology among students with high incidence disabilities

Disability clusters	N	ANOVA						
			Sum of Squares	Mean	Stand. Dev	Std. Error	F	Sig.
Students with speech and language deficits	47	Between Groups	105.634	6.6297	2.366224	0.224592	5.575	.000
		Within Groups	3529.166					
		Total	3634.800					
Students with learning disabilities	69	Between Groups	60.702	6.5495	2.399768	0.227776	3.286	.011
		Within Groups	3440.777					
		Total	3501.479					
Students with physical disabilities	58	Between Groups	244.671	6.55495	2.476755	0.235083	10.023	.000
		Within Groups	4546.541					
		Total	4791.212					
Students with hearing impairment	34	Between Groups	11.602	6.6018	2.582977	0.250249	1.094	.001
		Within Groups	1975.032					
		Total	1986.635					
Students with visual impairment	42	Between Groups	24.853	6.5855	2.274237	0.215861	1.342	.000
		Within Groups	3449.906					
		Total	3474.759					

*0.05 df 4

In Table 1 above, a one-way between-groups analysis of variance was conducted to explore the difference in the utilization of digital technology among students with high incidence disabilities as measured by Digital Divide and Integration (DDI). The respondents were categorized into five high incidence disabilities clusters Students with hearing impairment, Students with learning disabilities, Students with physical disabilities, Students with speech and language deficits and Students with visual impairment. There was a statistically significant difference at the $p < 0.05$ level in DDI scores for the five groups. Despite reaching a statistical significance, the actual size of mean scores between groups was small. The effect sizes calculated using eta squared ranged from 0.007 to 0.05 post-hoc comparisons using the turkey HSD test. They indicated that all groups though did not differ

significantly from each other but students with hearing impairment and visual impairment are the most disadvantaged in terms of capacity to utilize digital technology in the teaching-learning process. The low effect sizes may indicate a low level of support and development of competencies among all the groups. The low effect sizes may also indicate that no group is significantly supported in terms of building digital capacities for the digitalization of learning process in the university.

Table 2: Level of digital technology integration into the university teaching-learning process in terms of availability, utilization, accessibility and basic skills

S/NO	ITEM	Availability	Utilization	Accessibility	Basic Skills	Decision
1	Virtual classes through e.g. Zoom etc.	YES 42 (6%)	213 (28%)	265 (35%)	198 (26%)	LOW
		NO 708 (94%)				
2	Networked computer Lab	YES 168 (22%)	143 (19%)	159 (21%)	489 (65%)	LOW
		NO 582 (78%)				
3	Projectors	YES 126 (17%)	52 (7%)	67 (9%)	369 (49%)	LOW
		NO 624 (83%)				
4	Google classroom	YES 42 (6%)	38 (5%)	686 (91%)	491 (65%)	LOW
		NO 708 (94%)				
5	Student's institutional Email	YES 24 (5%)	18 (4%)	23 (5)	423 (85%)	LOW
		NO 476 (95%)				
6	Personal computers	YES 456 (61%)	395 (53%)	456 (61%)	301 (40%)	HIGH
		NO 294 (39%)				
7	Smart phones	YES 621 (83%)	621 (83%)	621 (83%)	698 (93%)	HIGH
		NO 129 (17%)				
8	University Wi-Fi for all	YES 123 (16%)	88 (11%)	88 (11%)	687 (92%)	LOW
		NO 627 (84%)				
9	Personal internet	YES 609 (81%)	609 (81%)	609 (81%)	750 (100%)	HIGH
		NO 141 (19%)				
10	Online tests/exams	YES 26 (3%)	20 (2%)	20 (2%)	122 (16%)	LOW
		NO 724 (97%)				
11	Departmental websites	YES 7 (1%)	5 (0.6%)	6 (0.8%)	723 (96%)	LOW
		NO 743 (99%)				
12	Television sets	YES 489 (65%)	301 (40%)	132 (18%)	748 (99%)	LOW
		NO 261 (35%)				
13	Student and staff's portal/dashboard	YES 19 (3%)	10 (1%)	17 (2%)	681 (91%)	LOW
		NO 731 (97%)				

Table 2 shows that there is a low level of digital technology integration into the university teaching-learning process in terms of availability, utilization, accessibility and basic skills. The data collected reveals that only teachers across the majority of the universities have access to university Wi-Fi, projectors, and networked computer laboratories. Up until now, there is only 6% zoom integration into teaching learning process especially for undergraduate programs. Only 3% adopt online testing, 1% of departments have websites and only 3% of the universities have improved correspondence system where students are reached through institutional emails.

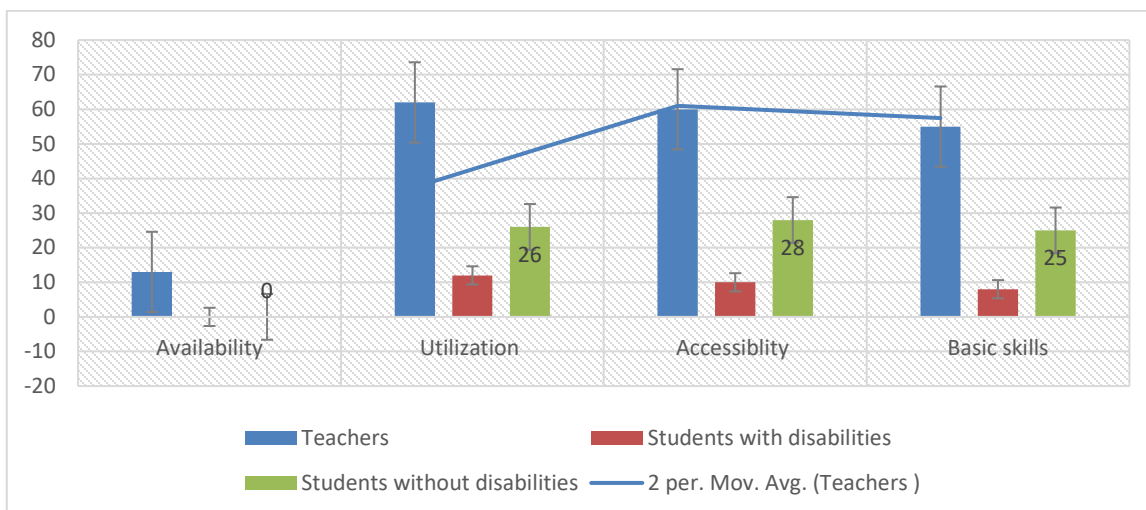


Figure 2: Level of digital technology integration into the university teaching-learning process

The figure 2 above shows the level of digital technology integration into the university teaching-learning process. The graph revealed that the availability of these technologies are as low as 13% in the university. The figure also shows that while 90% of the available technology tools are inaccessible by students with disabilities, utilization of such technology for learning is only about 12%. The abysmal low utilization may be explained in part by poor basic skills (8%) in the manipulation of these technologies. The low integration of digital technology into the teaching-learning process is also observed in the 26% and 28% and 25% of utilization, accessibility and basic skills requirement by students without disabilities.

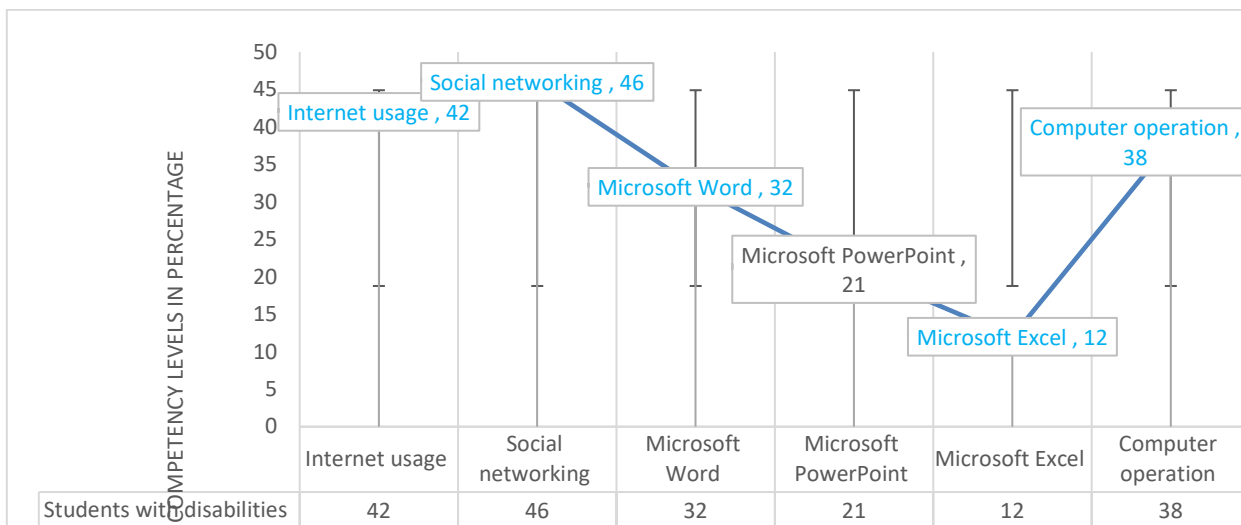


Figure 3: Competency levels in the use of digital technology among students with disabilities

Figure 3 shows that only 42% of university students with disabilities are competent in the use of internet to access online resources for learning purposes. A slightly higher percentage (46) uses digital technology for social networking and predominantly social media technologies. The result also shows that because of low competency, the use of Microsoft excel use is very low (12%). While 38% of university students with disabilities are computer literate, only 21% have competency in the use of Microsoft PowerPoint.

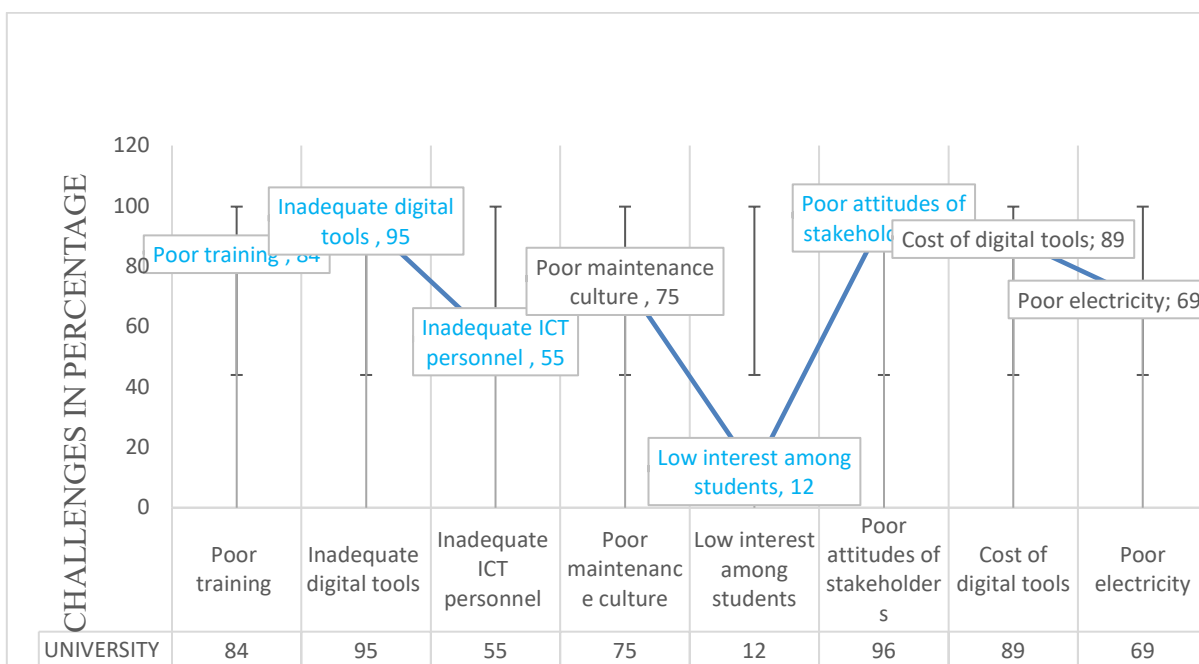


Figure 4: challenges militating against the digitalization of teaching-learning process

Figure 4 reveals that the biggest challenge militating against the digitalization of the teaching-learning process is poor attitudes of stakeholders towards the integration of digital technology into the teaching-learning process with 96% affirmation. This is closely followed by inadequate digital tools as well as the cost of these tools. It is also observed from the result that low integration of digital technology into teaching-learning process is not as a result of low interest among students but other factors such as poor training (84%), poor electricity (69%), poor maintenance culture among others.

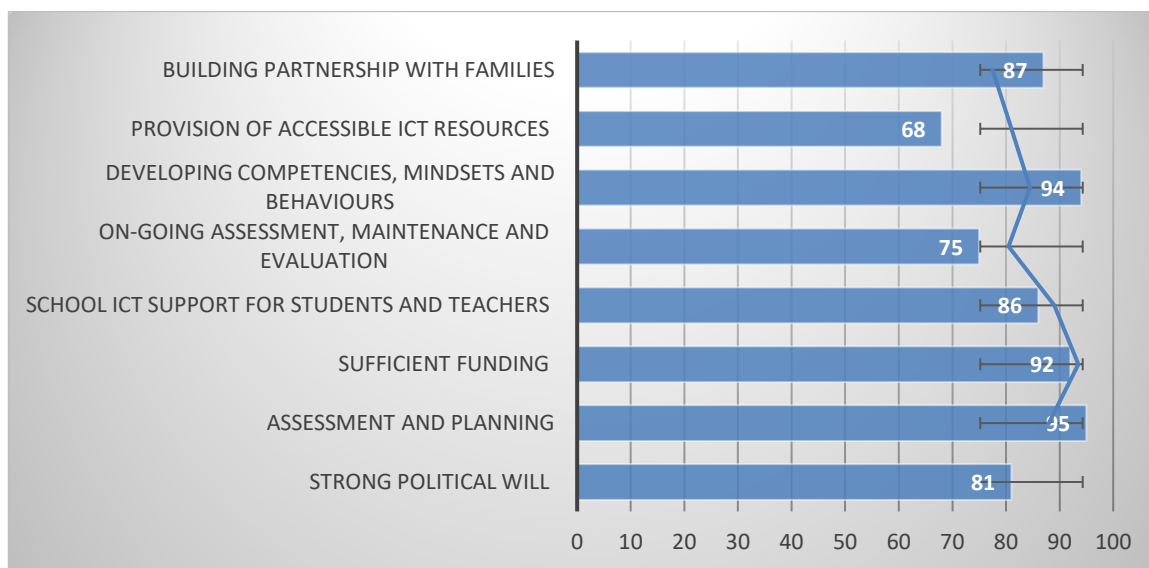


Figure 5: Approaches to close digital divide for university students with disabilities

Figure 5 above suggests that integration of digital technology into the university teaching-learning process begins from adequate assessment and planning with about 95% of the respondents affirming it. The result also shows that developing competencies, mindsets and behaviour is the second most important approach to the digitalization of university teaching and learning process. This might partly be the reason why there is low utilization of technology by students with disabilities from relatively high-income backgrounds. If the behaviour, competencies and mindsets of the managements of the universities are developed, they would be more opened to investing in digital technologies in line with global trends. Others bridges include sufficient funding, building partnerships with families, school ICT support for students and staff amongst others.

Discussion

The findings from the hypothesis revealed that the utilization of digital tech tools among students in five clusters of disability groups is very low which is an indication that there is a digital divide in integration and use of digital facilities in Nigerian Universities. This result is in line with others such as Fernandez et al (2023) who posited that persons with disabilities are denied access to virtually every facility in most sub-Saharan African countries. The present study also shows low support and competency among all cluster groups with more concern, it indicates low utilization of digital devices such as zoom for virtual classrooms, networked computer labs, Google classroom, online test/examinations, students/staff

portal/dashboard with percentage ranging from 2% to 35% however, smartphone, personal computers and internet are relatively high.

In Rizk and Hillier (2022), access to digital teaching-learning processes among students with disabilities is reported to be as high as 56, 73,61 for clusters like hearing impairments, visual impairments and learning disabilities respectively. while this is in support of the present study on access to Google classrooms, personal computers and internet with percentage ranges from 61% to 91% is still not impressive because 10 out of 13 digital facilities studied recorded extremely low access and utilization. The implications of these findings are that quality university education as a right is inaccessible to students with disabilities even in the 21st century where technology has open access to every aspect of the economy. Additionally, the mandate of international policies on education for persons with disabilities in not achieved and there is no plan of breaking the cycle of poverty among these categories in sight.

Just like most studies, it was revealed that the competency level of students with disabilities in the use of tech parameters like internet facilities, social media networks, Microsoft Word, Microsoft power points, Microsoft excel and computer operation is as low as from 21% to 46%. These are basic skills that indicate a level digital literacy as prerequisite for meaningful participation in the digital educational system. These basic computer skills should be part of the university curriculum and implemented in practical ways. This should be mandatory Deficits in these areas is an expression of lack of preparedness for activeness in digital world. Nieves (2021) correlates this study when it was reported that present school system digital era requires new skills to explore e-contents of educational materials from the global research community for personal advancement and achievement in contemporary competitive society.

The study is factual about the lack of access to the digitalization of the teaching-learning process as 21st century culture of university education. This threat is revealed in the findings that poor training, inadequate ICT tool, personnel, poor maintenance culture, lack of interest among students with disabilities due to low self-esteem, cost of digital tools, poor attitudes of stakeholders and poor electricity supply and connectivity. The average percentage of these digital divide variables is 71.5% which is an indication that only 28.5% of SWD in Nigerian Universities are not trapped by the force of digital divide. This trend is not just worrisome but project a bleak future as confirmed by JiYoungKim and Daniel (2021) Fernando and Botelho (2021), these studies found that accessibility for persons with disabilities is neither certain nor constant hence a conscious and systemic effort is required to ensure that the potentials of digital technologies for inclusion is realized. This further means that analysis of these challenges should be holistic and pattern of neglect of responsibilities by the system as well as change of indifferent attitudes to course of disability in Nigeria should be a priority.

Conclusion and recommendations

There is low integration of digital technology for students with disabilities which is partly due to poor competency in the use of digital tools. Challenges such as weak political will, inadequate digital tools, and poor assessment and planning were also identified in the study. Strong political will, integrated funding approach, and School ICT support for students and

teachers were identified as possible ways of bridging digital utilization gap. The suggested that no group is significantly supported in terms of building digital capacities for the digitalization of the learning process in the university. Based on the findings, these recommendations among others are made:

- Stakeholders particularly the Government should be thoughtful, purposeful and deliberate in planning, and assessing ICT needs of students in consonance with profile of each disability.
- ICT allowance for students with disabilities should be considered a priority by institutions and relevant stakeholders like cooperate bodies, Civil Society Organizations, Non-Government Organizations etc.
- A roadmap to comprehensive and consistent digital literacy for SWD should be drawn and implemented by experts with due consideration to measures validated in this study in addition to other research-based strategies.

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Skills required in higher education to prepare graduates for the Fourth Industrial Revolution workforce

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Abstract

The Fourth Industrial Revolution is resulting in drastic changes to the way the world works today. Since everything is changing quickly, higher education institutions must move quickly to prepare students for employment in the Fourth Industrial Revolution. The study reviewed the skill set needed for the employment of South African graduates during the Fourth Industrial Revolution. A scoping review was conducted on published research on teaching and learning practices to identify the skills needed to prepare graduates for the Fourth Industrial Revolution workforce. A set of 25 skills were identified in seven categories. The study also conducted a content analysis on the 2022 yearbooks of three qualifications (in Science, Social Science, and Commerce) at the University of Johannesburg to find out which of the identified Fourth Industrial Revolution skills are included. The study shows that none of the qualifications (not even the BSc in Computer Science and Informatics with Artificial Intelligence) incorporated all the identified skills for the Fourth Industrial Revolution. Recommendations are made to introduce fundamental modules that will cover all the Fourth Industrial Revolution skills that are not included in the curricula. Whilst the country and the world at large are still adapting to the Fourth Industrial Revolution, the Fifth Industrial Revolution is underway, and this will bring more changes and different skill sets that might be needed for future employability. Universities must constantly assess their curricula and amend them where necessary as new skills are needed, and new careers emerge with these changes in society.

Keywords: 4IR Skills, 4IR Workforce, University Curricula, Graduate Employment

Introduction

The development of the Fourth Industrial Revolution (4IR) is fast and complex, as never before experienced in the history of humankind (Schwab, 2017). The main invention of the 4IR is the advancement of the internet and technology. With the changes and many social injustices we are facing today, it is therefore very important to understand the technological revolution that is changing our way of life (Wessels and van Wyk, 2022). The 4IR has had a big impact on the functions and operations of universities, and it is predicted that in the future more jobs done by humans will be done by machines (Ford, 2015).

Graduates need new skills for the workforce with the 4IR and they will have to keep learning new skills as they arise to remain employed. As stated by Sledge and Fishman (2014) “*Lifelong learning will become a permanent part of our professional lives*”. Higher education is facing a big challenge in preparing students for employment with the 4IR markets (Wessels and van Wyk, 2022). Universities must provide students with quality education and connect them with external practice. This will help students to gain the experience needed for employment. Universities need to shift their focus from students graduating to student employability in the 4IR (Sledge and Fishman, 2014).

This research aims to determine how higher education institutions prepare and equip students with the skill set needed for employment in the 4IR. A literature review was conducted to identify skills needed in the 4IR. The curriculum structure of three degrees from the University of Johannesburg were analysed to determine how the skills are incorporated into the curricula.

Problem statement and research questions

The skills needed for the 4IR are different from what was needed before, and universities have to change their curricula to accommodate these required skills for student employment in the 4IR. The following research questions were derived, taking into consideration the need for a better understanding of the 4IR and how well South African universities are adapting to preparing graduates for the 4IR.

1. Which skills should be introduced to South African higher education institutions to prepare the graduates for future employment during the 4IR?
2. How well do current degrees accommodate these required skills?

Methodology

The scoping review method was used to implement the five phases adopted by Arksey and O’Malley (2005) to determine which skills should be introduced by South African universities to prepare graduates for employment in the 4IR.

1. Identifying the research question,
2. Pick out relevant research,
3. Study selection,
4. Arranging the data,
5. Organising and summarising the results.

The purpose of the scoping review was to include all available studies and research on the topic under investigation. This method is suitable for this research project because the 4IR is a newly debated phenomenon, and we are not sure how it will change our way of living in the future.

The research used content analysis to look at the curricula for the year 2022 to find out if the university has incorporated some of the skills needed for the 4IR into its curricula. Holsti (1969) defines content analysis as, “*any technique for making inferences by objectively and*

systematically identifying specified characteristics of messages”. The research focuses on three degrees from the Faculty of Science, the Faculty of Humanities, and the College of Business and Economics. The data was collected from yearbooks, which were obtained via email from the Head of Administration of the University of Johannesburg.

Degrees that the study covered:

1. BSc in Computer Science and Informatics with Artificial Intelligence (B2I04Q) from the Faculty of Science.
2. BA with specialisation in Politics, Economics, and Technology (B7024Q) from the Faculty of Humanities.
3. BCom in Accounting (B3A17Q) from the College of Business and Economics.

Literature survey

Schwab (2017) argues that although the 4IR is very disruptive to higher education, it is in our power to change our ways of learning and teaching to flourish in this new environment. As the higher education sector, we have a critical role to play in helping society to adapt to emerging technologies (Masinde and Soux, 2020). New skills are needed due to technologies such as artificial intelligence that were not needed in the third industrial revolution.

Artificial intelligence is the heart of the 4IR, but very few schoolchildren even have access to computers, with some learners in South Africa completing grade 12 without ever using a computer (Oke and Fernandes, 2020). According to Gray (2016), graduates will need to adapt to new skills to take full benefit of the 4IR. To survive as an employee in this era, one needs to understand numeracy, literacy, and how the world operates (Butler-Adam, 2018). Students who are studying basic and applied sciences need to learn politics and social sciences, and students studying in the faculty of humanities and social sciences must learn the basics of artificial intelligence (Butler-Adam, 2018).

Scoping review

The scoping review aimed to identify and summarise skills that graduates must possess for employability in the 4IR era. There is a gap between the skills of university graduates and the skills required by employers from graduates (Succi and Canovi, 2022). The sections below explain how the review identified and summarised the skills.

Identifying the research question and sub-questions

The questions used to guide the research were:

1. Which skills are needed in the 4IR?
2. Which skills should be introduced to higher institutions to prepare the graduates for future employment during the 4IR?

Identifying relevant research literature

All articles used for the scoping review were searched on Google Scholar and ResearchGate, using the keywords: “4IR skills”, “industry 4.0 skills” and “the Fourth Industrial Revolution skills”. The research includes journal articles published in English from 2016 to 2023. After closely reading their abstracts, keywords, and conclusions, only 15 journal articles were selected for further analysis. Note that articles in suspected predatory journals were excluded from the analysis.

Skills for the Fourth Industrial Revolution

The findings presented in this part of the research are based on data extracted from 15 journal articles (see Table 1). The research has identified 25 skills needed for the 4IR. The list below categorises the 4IR skills as summarised in Table 1:

1. Statistics or data science (STADS): Students must have the ability to transform data into information, and be able to analyse, interpret and use it to predict the future.
2. Computer science or information management (COMSCI): Students need to have basic skills in computer science; they do not have to know how to build a new game, but at least be able to go into a database and write simple code to analyse the data properly (Barac, Plant and Olivier, 2021).
3. Artificial intelligence and robotics (AIR): Artificial intelligence is a driving force for the 4IR, and it is therefore important for students to have these skills for their employability. The world is currently witnessing the use of generative artificial intelligence such as ChatGPT in research, solving mathematical problems, and solving real-life problems in social sciences and arts and culture fields (Morandini, Fraboni, Angelis, Puzzo, Gisino and Pietrantonio, 2023; Koopman, 2022; Mijwil, Ali and Sadikoglu, 2023).
4. Mathematics (MAT): Students must be able to use knowledge, facts, and data to solve problems effectively (Kačmakovic and Lokaj, 2021).
5. Language (LANG): Students and employees must have good communication skills, either verbal or written.
6. Human resources and management (HRM): The ability to work well with others and build good working relationships.
7. Psychology (PSYC): The ability to understand and manage emotions, strengths, and belief systems and be able to adapt to changes as they arise (Kamaruzaman, Hamid, Mutalib and Rasul, 2022).

Table 1: Linking the 4IR skills to the subjects taught in higher institutions.

Skill category	Skill	Source
1. STADS	Modelling	(Barac et al., 2021)
	Data mining, analysis, interpretation, and visualization	(Barac et al., 2021; Kipper, Iepsen, Forno, Frozza, Furstenau, Agnes and Cossul, 2021; Urquhart and Surianarain, 2021)
	The ability to transform data into information	(Mabe and Bwalya, 2022)
	Being familiar with big data systems	(Mabe and Bwalya, 2022)
	Forecasting	(Succi and Canovi, 2020)
2. CMSC	Cloud computing	(Barac et al., 2021; Gray, 2016)
	Digital mindset and coding	(Barac et al., 2021; Kipper et al., 2021; Tsiligiris and Bowyer, 2021)
	Software development	(Urquhart and Surianarain, 2021)
	Network and information security	(Urquhart and Surianarain, 2021)
3. AIR	Fundamental concepts of AI	(Gray, 2016; Morandini et al., 2023)
	Generative AI	(Koopman, 2022; Morandini et al., 2023; Mijwil et al., 2023; Aljanabi, 2023)
	Robotics	(Mijwil et al., 2023)
4. MAT	Complex problem solving	(World Economic Forum, 2016)
	Logical reasoning and mathematical reasoning	(World Economic Forum, 2016; Kipper et al., 2021)
5. LANG	Communication	(Kačamakovic and Shehu Lokaj, 2021; Kamaruzaman et al., 2022; Succi and Canovi, 2020; Karsten, Steenekamp and van der Merwe, 2020; Kipper et al., 2021)
	Culture adaptability	(Succi and Canovi, 2020)
6. HRM	Negotiation	(Succi and Canovi, 2020; Gray, 2016)
	Work ethic	(Kačamakovic and Shehu Lokaj, 2021)
	Collaboration	(Karsten et al., 2020; Kipper et al., 2021)
7. PSYC	Being stress tolerant	(Succi and Canovi, 2020)
	Being able to balance life	(Succi and Canovi, 2020; Kipper et al., 2021)
	Adaptability to change	(Succi and Canovi, 2020; Tsiligiris and Bowyer, 2021)
	Being self-aware	(Succi and Canovi, 2020; Kipper et al., 2021)
	Positive attitude	(Kačamakovic and Shehu Lokaj, 2021)
	Emotional intelligence	(Karsten et al., 2020; Kipper et al., 2021; Gray, 2016; Tsiligiris and Bowyer, 2021)

Content analysis

This section analyses the undergraduate yearbooks from the University of Johannesburg. The main aim of this analysis is to find out if the 4IR skills identified in Table 1 are incorporated into the university's curriculum.

BSc in Computer Science and Informatics with Artificial Intelligence (B2104Q)

This qualification is designed to provide students with an education that equips them with knowledge, theory, and methodology of information technology. Its purpose is to develop

qualified scientists who can identify, analyse and solve problems associated with information technology (University of Johannesburg, 2022a). Refer to Figure 1 in Appendix A for the academic structure of the BSc in Computer Science and Informatics with Artificial Intelligence; students have 18 compulsory modules and four elective modules in their second year.

Table 2 provides an analysis of how each of the skills identified in Table 1 is met by the modules of the degree B2104Q. The analysis shows that 52% of the identified skills required for the 4IR are included in the curriculum of the BSc Computer Science and Informatics with Artificial Intelligence. 48% of the skills are not included in this qualification, six of which are from Psychology.

BA with specialisation in Politics, Economics, and Technology (B7024Q)

This qualification aims to equip students with the skills and knowledge needed to function in the new environment and be aware of the interplay of technology and society. Graduates will have high-order skills to navigate the complexity of the 4IR (University of Johannesburg, 2022b). The curriculum for the BA with specialisation in Politics, Economics, and Technology programme consists of 50 semester modules but students can only do 22 of these modules, see Figure 2 in Appendix A. The curriculum has nine compulsory modules, three of which are technology based. There are 18 technology-based modules that consist of three sets; a student must choose one set and continue with it until the third year. The remaining 20 modules consist of five sets each student must choose one set that will continue into their second year.

Table 2 provides an analysis of how each of the skills identified in Table 1 is met by the modules of the degree B7024Q. The analysis shows that 84% of the identified skills required for the 4IR are included in the curriculum of the BA with specialisation in Politics, Economics, and Technology. Most of these skills are covered in the elective modules. The remaining 16 percent is from mathematics; students doing this qualification will not have any mathematical skills.

BCom in Accounting (B3A17Q)

This qualification provides students with knowledge for solving problems in auditing, accounting, and taxation (University of Johannesburg, 2022c). This qualification consists of 28 compulsory modules, three of which are year modules and 25 are semester modules (University of Johannesburg, 2022c). Refer to Figures 3 and 4 in Appendix A for the academic structure of this qualification. Table 2 provides an analysis of how each of the skills identified in Table 1 is met by the modules of the degree B3A17Q. 84% of the identified skills for the 4IR are included in this qualification, and 16 percent of the skills are not included, see Table 2.

Table 2: Linking the 4IR skills to the subjects taught in higher institutions.

Skill category	Skills	B2I04Q	B7024Q	B3A17Q
1. STADS	Modelling skills	Statistics 2A and 2B	Information Systems, and Analytical Techniques, Information Management 3A	4IR Accounting
	Data mining, analysis, interpretation, and visualisation	Machine learning	Information Management, Informatics, and Information Systems	4IR Accounting, Business Information Systems 2A, and 2B
	The ability to transform data into information	Statistics 1A, 1B, 2A and 2B	Information Management, Informatics, and Analytical Techniques	4IR Accounting, Business Information Systems 2A, and 2B
	Being familiar with big data systems	Machine learning	Information Management, Informatics, and Information Systems	Business Information Systems 2A and 2B
	Forecasting	Not included in the curriculum	Information Systems	4IR Accounting
2. CMSC	Cloud computing	Computer Science 3A	Information Systems, and Informatics 3A and 3B	Not included in the curriculum
	Digital mindset and coding skills	Computer Science 1A, 1B, and Informatics 1A, 1B	Information Management, Informatics 1A, 1B, Information Systems, and Information Portals	4IR Accounting, Business Information Systems 2A, and 2B
	Software development	Computer Science 2A	Informatics, Information Systems, and Information Portals	Business Information Systems 2A and 2B
	Network and information security	Information Management 2A and 2B	Information Systems	4IR Accounting, Business Information Systems 2A, and 2B
3. AIR	Fundamental concepts of AI	Computer Science 2D	Not included in the curriculum	Not included in the curriculum
	Generative AI	Not included in the curriculum	Not included in the curriculum	Not included in the curriculum
	Robotics	AI Project	Not included in the curriculum	Not included in the curriculum
4. MAT	Complex problem solving	Mathematics 1A, 1B	Information Systems	Introductory Mathematical Analysis A
	Logical and mathematical reasoning	Mathematics 1A, 1B	Not included in the curriculum	Introductory Mathematical Analysis A
5. LANG	Communication	AI Project (Written communication)	Strategic Communications, Politics, Social Media Management	Ethical Foundation to Commerce 2B.
	Culture adaptability	Not included in the curriculum	Politics, Social Media Management	Ethical Foundation to Commerce 2B.
6. HRM	Negotiation	Not included in the curriculum	Entrepreneurship and Social Media Management	Business Management 1A, 1B

	Work ethic	Not included in the curriculum	Knowledge Economy, Entrepreneurship	Governance and Control 2A
	Collaboration	Not included in the curriculum	Knowledge Economy, Entrepreneurship	Business Management 1A, 1B, Commercial Law 1A, and 1B
7. PSYC	Being stress tolerant	Not included in the curriculum	Sociology	Ethical Foundation to Commerce 2B.
	Being able to balance life	Not included in the curriculum	Philosophy, and Sociology	Ethical Foundation to Commerce 2B.
	Adaptability to change	Not included in the curriculum	Social Media Management and Philosophy	Ethical Foundation to Commerce 2B.
	Being self-aware	Not included in the curriculum	Philosophy	Ethical Foundation to Commerce 2B.
	Positive attitude	Not included in the curriculum	Philosophy, and Sociology	Ethical Foundation to Commerce 2B.
	Emotional intelligence	Not included in the curriculum	Sociology	Ethical Foundation to Commerce 2B.

Summary of the research findings

The research identified and summarised 25 skills that graduates must have for employability in the 4IR era. The identified skills were grouped into seven categories of modules taught in universities. The research also analysed three qualifications from the University of Johannesburg from three different faculties to find out if the 4IR skills identified in Table 1 are incorporated into the university's curriculum. The three qualifications that were analysed are:

1. BSc in Computer Science and Informatics with Artificial Intelligence (B2I04Q)
2. BA with specialisation in Politics, Economics, and Technology (B7024Q)
3. BCom in Accounting (B3A17Q)

48% of the 4IR skills are not included in the BSc curriculum; this includes skills from psychology, human resources, and management. Students may have difficulties adapting to culture and getting along with fellow employees in the future. They may also find it difficult to deal with social issues such as stress and adapt to change. 16% of the 4IR skills are not included in the BA curriculum; students doing this qualification will not have covered any logical reasoning or mathematical reasoning skills in their studies. 84% of the 4IR skills included in the BA curriculum are covered in the elective modules. 16% of the 4IR skills are not included in the BCom curriculum.

Recommendations

The University of Johannesburg offers the following free online course for students and employees: Artificial Intelligence in the 4IR. In this course, students can work at their own pace that is most convenient to them.

Based on the findings of this study, the following recommendations are made:

1. Artificial intelligence in the 4IR course should be made compulsory for all students with BCom and BA qualifications.
2. An Artificial Intelligence and Robotics module should be added to the BSc qualifications as an elective module.
3. A fundamental course in human management and psychology should be introduced that is compulsory for all the students doing the BSc degree. This course can be offered online similar to the artificial intelligence in the 4IR course with formal or informal assessment and students can choose to do it anytime during the period of their qualification. This module must include all the 4IR skills not included in the BSc curriculum.
4. A fundamental course in mathematics should be introduced that is compulsory for all BA students regardless of whether the student did mathematics or mathematical literacy in grade 12. The purpose of this module is to give students mathematical and logical reasoning skills for BA studies. This course can be offered online with an online formal or informal assessment and students can choose to do it anytime during the period of their qualification but within a certain time frame.

The introduction of artificial intelligence in the workforce has a very high risk of automating and reducing tasks that are currently performed by humans and therefore increasing the unemployment rate in South Africa. A recommendation is suggested that higher institutions host more public lectures to keep students and their employees more informed of the new skills that are emerging, as it might take a while before the skills are incorporated into the student's curriculum. Generative AI, such as ChatGPT, is a new

phenomenon because of the development of artificial intelligence in the 4IR, and there are many opportunities for this phenomenon to improve our lives.

Future work

1. **The impact of the 4IR on the current workforce:** The 4IR is changing every industry across the world, and these changes bring along transformation of the entire systems within workplaces. Some of the research questions that can be investigated under this topic include:
 - a. How are companies/organisations equipping their employees with skills for the 4IR?
 - b. Are the current workforce and businesses being prepared adequately for life in the 4IR?
2. **The Fifth Industrial Revolution (5IR):** The 5IR is more of a collaboration rather than a competition between humans and machines (Noble, Mende, Grewal and Parasuraman, 2022). Some researchers believe that the Covid-19 pandemic has pushed the world to the 5IR (Javaid, Haleem, Singh, Haq, Raina and Suman, 2020).

Research questions that can be investigated under this topic:

- a. What pushed us to the 5IR?
- b. How is the 5IR different from the 4IR?
- c. Will the 4IR skills still be adequate during the 5IR era?

Conclusion

Universities are under pressure to produce graduates that are employable during the 4IR. University qualifications must be reconstructed to provide students with the relevant skills needed for the 4IR. The aim of this study was to review the skills needed for the employment of South African graduates during the 4IR. The research identified and summarised 25 skills needed for the 4IR from 15 published articles. The skills were grouped into six categories of subjects taught in universities. The research further analysed three undergraduate qualifications from the University of Johannesburg to find out if these skills are incorporated into the curricula.

The study shows that not all the identified skills for the 4IR are incorporated in the three qualifications analysed. The BA qualification has 84% of the 4IR skills incorporated in core and elective modules. If a student chooses to do information systems in their first year, they must do it in their second and third year, and they will not have skills incorporated in informatics or information portals. The BSc qualification has 52% of the 4IR skills; most of the skills not incorporated fall under the psychology skills category. The BCom qualification has 84% of the 4IR skills incorporated in the curricula in core and elective modules. Recommendations are made that the suggested fundamental modules be made compulsory, as explained under recommendations. With these recommended modules, students will graduate with most, if not all, of the 4IR skills needed for employment.

Universities that embrace the developments of the 4IR and incorporate the 4IR skills in their curricula to ensure that students get employment could expand their markets (Wessels and van Wyk, 2022). The 4IR is more than just the use of smart devices or computers; one needs a collective set of skills for employability. South Africa, and the world at large, is still adapting to the changes that came with the 4IR, but the 5IR is already underway. This may bring more changes to our way of life. Universities must

constantly review their curriculum and amend it where necessary as new skills and careers become in demand. In 2016, the World Economic Forum (2020) estimated that 65% of children who were starting primary school would end up in careers that did not exist when they started. Data science is one of the careers that are in demand currently and was not in demand back in 2016. Universities are currently introducing data science courses for students. The University of Johannesburg has recently launched the Centre for Applied Data Science which offers a Masters in Applied Data Science that started in 2023 (University of Johannesburg, 2022). The University of South Africa has introduced an Applied Data Science module in 2022 offered at Honours level.

It is believed that the 5IR will involve a collaboration between machines and humans instead of humans competing with machines for employment (Noble et al., 2022). The co-founder of Universal Robots says: “*Industry 5.0 (5IR) will make the factory a place where creative people can come and work, to create a more personalised and human experience for workers and their customers*” (Regenesys Business School, 2020). Even though we are not sure how different it is from the 4IR, it cannot be avoided, we therefore need to embrace it. In conclusion, improving the quality of education in South Africa will bring significant change.

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Appendix A

Course content of the BSc qualification

4.1.5	Bachelor of Science in Computer Science and Informatics with Artificial Intelligence	B2I04Q
FIRST YEAR		
First Semester		
Computer Science 1A Informatics 1A Mathematics 1A Statistics 1A		
Second Semester		
Computer Science 1B Informatics 1B Mathematics 1B Statistics 1B		
SECOND YEAR		
First Semester		
Computer Science 2A Mathematics 2A1, 2A2		
Second Semester		
Computer Science 2D Mathematics 2B1, 2B2		
Choose one <u>set</u> of elective modules		
One semester module or its equivalent, per semester chosen from the elective modules listed below provided the appropriate prerequisites have been met:		
Information Management 2A Statistics 2A		
Information Management 2B Statistics 2B		
Any other combination of four second year Mathematics modules that may be approved <i>ad hoc</i> provided there are no timetable clashes, and the necessary prerequisites are adhered to.		
THIRD YEAR		
First Semester		
Computer Science 3A Machine Learning		
Second Semester		
Computer Science 3D AI Project		

Figure 1: Curriculum structure of BSc Computer Science and Informatics with AI

Course content of the BA qualification

First Year	Second Year	Third Year	Semester modules
Politics 1A&1B	Politics 2A&2B	Politics 3A&3B	6
Economics 1A&1B	Economics 2A&2B	Economics 3A&3B	6
Information Portals & Search Engine Optimisation or: Information Systems 1A&1B or: Informatics 1A&1B	Social Media Management & Knowledge Economy or: Information Systems 2A&2B or: Informatics 2A&2B	Information Management 3A&3B or: Information Systems 3A&3B or: Informatics 3A&3B	6
Philosophy 1A&1B or: Sociology 1A&1B or: Strategic Communication 1A&1B or: History 1A&1B or: Analytical Techniques 1A&1B	Philosophy 2A&2B or: Sociology 2A&2B or: Strategic Communication 2A&2B or: History 2A&2B or: Entrepreneurship 2A&2B		4
8 semester modules	8 semester modules	6 semester modules	22

Figure 2: Curriculum structure of BA with specialisation in Politics, Economics, and Technology

Course content of the BSc qualification

FIRST YEAR					
SEMESTER MODULES PRESENTED OVER A YEAR					
FIRST SEMESTER			SECOND SEMESTER		
MODULE NAME	MODULE CODE	NQF CREDITS	MODULE NAME	MODULE CODE	NQF CREDITS
Accounting 1A	ACC01A1	12	Accounting 1B	ACC01B1	12
Business Management 1A	BMA11A1	12	Business Management 1B	BMA21B1	12
Commercial Law 1A	COL41A1	16	Commercial Law 1B	COL41B1	16
Economics 1A	ECO01A1	12	Economics 1B	ECO01B1	12
Introductory Mathematical Analysis A	MAA00A1	12	Financial Management 1B	FNM1B01	12

SECOND YEAR		
SEMESTER MODULES PRESENTED OVER A YEAR		
MODULE NAME	MODULE CODE	NQF CREDITS
Taxation 2AB	TAX2B00	12

SEMESTER MODULES					
FIRST SEMESTER			SECOND SEMESTER		
MODULE NAME	MODULE CODE	NQF CREDITS	MODULE NAME	MODULE CODE	NQF CREDITS
Accounting 2A	ACT02A2	12	Accounting 2B	ACT02B2	12
Business Information Systems 2A	BIS22A2	8	Business Information Systems 2B	BIS22B2	8
Governance and Control 2A	GAC02A2	12	Ethical Foundation to Commerce 2B	EFC02B2	8
Management Accounting Strategy 2A	MAS02A2	12	Management Accounting Strategy 2B	MAS02B2	12
Financial Management 2A	FNM22A2	12	Cost and Management Accounting 2B	CMA02B2	12
1 Semester Module presented over a year				120 Credits	
10 Semester Modules					

Figure 3: Curriculum structure of BCom in Accounting

THIRD YEAR					
YEAR MODULES					
MODULE NAME		MODULE CODE		NQF CREDITS	
Accounting 3AB		ACC3AB0		32	
Governance and Control 3AB		GOC3AB0		32	
SEMESTER MODULES					
FIRST SEMESTER			SECOND SEMESTER		
MODULE NAME	MODULE CODE	NQF CREDITS	MODULE NAME	MODULE CODE	NQF CREDITS
Cost and Management Accounting 3A	CMA03A3	16	Financial Management 3B	FNM03B3	16
Taxation 3A	TAX03A3	16	Taxation 3B	TAX03B3	16
			4IR Accounting	ACCAIRB	6
2 Year Modules and 5 Semester Modules				134 Credits	

Figure 4: Curriculum structure of BCom in Accounting

Examining the readiness of learning management systems in developing personalised learning paths

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Abstract

Although digital technologies ensured that learning continued for universities and schools during COVID pandemic-mandated closures, post-pandemic levels of “learning poverty” observed in various poorer countries across the globe highlight the need for more outstanding and significant meaningful support for both teachers and students in the learning process. One form of such support includes the offering of personalised learning paths. This paper provides a systematic literature review on the Learning Management Systems (LMSs) at twenty-six public universities in South Africa. The aim is to examine the readiness of these LMSs to create effective personalised learning paths. Results reveal limitations that prevent students from benefiting from effective personalised learning paths. There is a need to collect and identify the appropriate data that will play a role in determining how best to present content to a particular type of student, prompting the need for an e-learning model that is enhanced by additional sources of student data.

Keywords: Personalised learning paths, Learning Management Systems, adaptive learning.

Introduction

Central to many universities’ infrastructure for building learning environments are Learning Management Systems (LMSs). LMSs are enterprise software solutions with features that facilitate flexible course delivery, communication, conferencing, assessments, student management, student support, and increased teaching efficiency (Coates et al., 2005). LMSs saw widespread adoption by universities in the 2000s. Today, there are over 500 variations of LMSs. LMSs perform education activities that enable learning and teaching unbound by time and geography (Gamage et al., 2022). During the COVID-19 lockdown, digital technologies ensured that learning could continue in universities and schools. However, post-pandemic levels of “learning poverty” observed in various poorer countries highlight the need for more significant and meaningful support for teachers and students in the learning process, including offering personalised learning opportunities (Education, 2020; World-Bank, 2023).

The improvements and accessibility of Artificial Intelligence (AI) and Big Data Analytics have raised an appetite for LMS space to focus on creating personalised, conducive learning environments that consider each individual’s ability to apply a suitable learning pedagogy, thus improving that individual’s learning process (Aldahwan & Alsaeed, 2020). This appetite is particularly pertinent with increasingly diverse students in the classroom. For example, Industry 5.0 has prompted more students from different disciplines to be interested in developing human-centric problem-solving skills

linked to information technology (Carayannis & Morawska-Jancelewicz, 2022). An LMS will be more successful in its engagements by offering personalised learning paths derived by considering its students' needs, strengths, weaknesses, and interests (Shemshack & Spector, 2020). Thus, researchers have observed a deficiency in collecting, identifying, and analysing richer student data by the LMS to enable the generation of more meaningful, adaptive, personalised learning and teaching offerings (Tetzlaff et al., 2021; Mpungose et al., Matariran et al.).

Some LMSs have made impressive inroads in adapting to student's needs, but others are lagging. Compounding the challenge for universities in switching from one LMS to another as an undertaking that is not easily done. Due to potentially high costs, the need for training, and likely resistance from staff members who must continuously adjust to the new LMS environment (Coates et al., 2005). As part of a more extensive study which seeks to develop a framework for LMSs to reference when developing personalised learning features driven by student data, this paper systematically reviews the LMS platform choices of the twenty-six public universities in South Africa to develop recommendations aimed at identifying commonly collected student data and discovering any gaps when personalising these LMSs.

The paper is structured as follows: firstly, we provide background into personalised learning paths. Then, a discussion of the research method, followed by the LMSs review, results analysis, and the conclusion drawn.

Personalised learning paths

A learning path is a set of learning activities a student performs to achieve knowledge and is essential for meeting each student's behavioural approach to learning (Sun et al., 2008; & Garrido, 2015). Learning paths help to improve student performance, design curricula, and identify learning difficulties in students (Lumy et al., 2022; Ramos et al., 2021). Furthermore, learning paths can be used to analyse students' behaviour patterns within an LMS and classify students into specific categories to support their needs better, thus providing a feedback mechanism for lecturers to revise their approach as necessary (Lumy et al., 2022). Personalisation considers the characteristics of the individuals and the diversity of their needs (Vanithaa & Krishnanb, 2019). Thus, personalised learning paths are implemented specific to students' character and needs, consequential to a significant role in personalised learning (Lumy et al., 2022).

Lumy et al. (2022) showed that students tend to perform better when given the flexibility offered by learning paths in personalised learning offerings, with increased success. As Higher Education Institutions (HEIs) struggle with high dropout rates among students, maintaining the status quo and continuing to use LMSs in the traditional "one-size-fits-all" manner it was initially developed for is no longer a responsible approach (Dyomfana, 2022; Lumy et al., 2022). Personalised learning paths enable LMSs to suit students from diverse backgrounds at all computer literacy levels. Personalised paths can motivate, sustain interest, and help students complete their studies (Vanithaa & Krishnanb, 2019). As noted by Mpungose et al. (2022) and Matarirano et al. (2021), learning should also consider personal (non-formal) experiences and external factors such as social life, positive attitude or computer self-efficacy, which motivate students to use the LMS.

Research method

This study follows the guideline for a systematic literature review in software engineering as outlined by Kitchenham & Charters (2007) to identify the knowledge gaps concerning appropriate personalised learning paths for LMSs—the guidelines cover three phases: planning, conducting and reporting the review. The three phases feature the research question(s), review method(s), search strategy, documentation of the search strategy, explicit exclusion and inclusion criteria, and the quantitative meta-analysis.

Research question

This paper reviews current research on personalised learning paths on LMSs employed at public universities in South Africa. The review seeks to answer the following Research Questions (RQ):

1. Are the implemented learning paths personalised?
2. How adaptive are the learning paths to meet students' specific needs?
3. Does the LMS have valuable data that can be used to build learning paths beneficial to students?

Review method

The review was limited to addressing the shortcomings of the LMSs used by universities in South Africa. As such, the study began by visiting the websites of each of the twenty-six universities to identify the LMS used. This review yielded five different LMS platforms: Blackboard, Brightspace, Canvas, Moodle, and Sakai, as illustrated in Table 1.

Table 3. LMSs used by HEIs in South Africa

Learning Management System	Higher Education Institution
Blackboard (Commercial)	Cape Peninsula University of Technology Central University of Technology Mangosuthu University of Technology Seafako Makgatho Health Sciences University University of Fort Hare University of Johannesburg* University of Limpopo University of Pretoria (clickUP) University of the Free State
Brightspace (Commercial)	University of Cape Town Tshwane University of Technology
Canvas (Commercial)	University of Witwatersrand (ulwazi)
Moodle (Open Source)	Durban University of Technology (TLZ) Mangosuthu University of Technology Nelson Mandela Metropolitan University Rhodes University Sol Plaatje University Stellenbosch University (SUNLearn) University of Johannesburg* University of KwaZulu-Natal University of Mpumalanga University of South Africa University of Venda (Digikamva) Durban University of Technology (TLZ) University of Zululand Vaal University of Technology Walter Sisulu University
Sakai (Open Source)	University of the Western Cape (Ikamva) North-West University (eFundi)

** It should be noted that the University of Johannesburg has announced plans to switch to Moodle.*

The study proceeded with a literature review on the identified five LMSs. Primarily, the Web of Science was used to conduct searches for articles using the keywords “LMS” (where LMS was replaced by one of the five LMSs identified) and “learning paths”. In addition, to ensure that results only came from recent studies, the searches were limited to publications between 2017 and 2023.

As noted in Figure 1, the Web of Science library yielded considerable results for each LMS. However, after skimming the abstracts of the research papers returned for each LMS, it was noted that the initial search results for Brightspace and Canvas did not meet the purposes of the review. As a result, further searches were conducted on Scopus and other search platforms, respectively. The search strategy ultimately led to identifying appropriate resources on learning paths for each LMS, as documented in Table 2. The findings of each LMS are summarised in the next section.

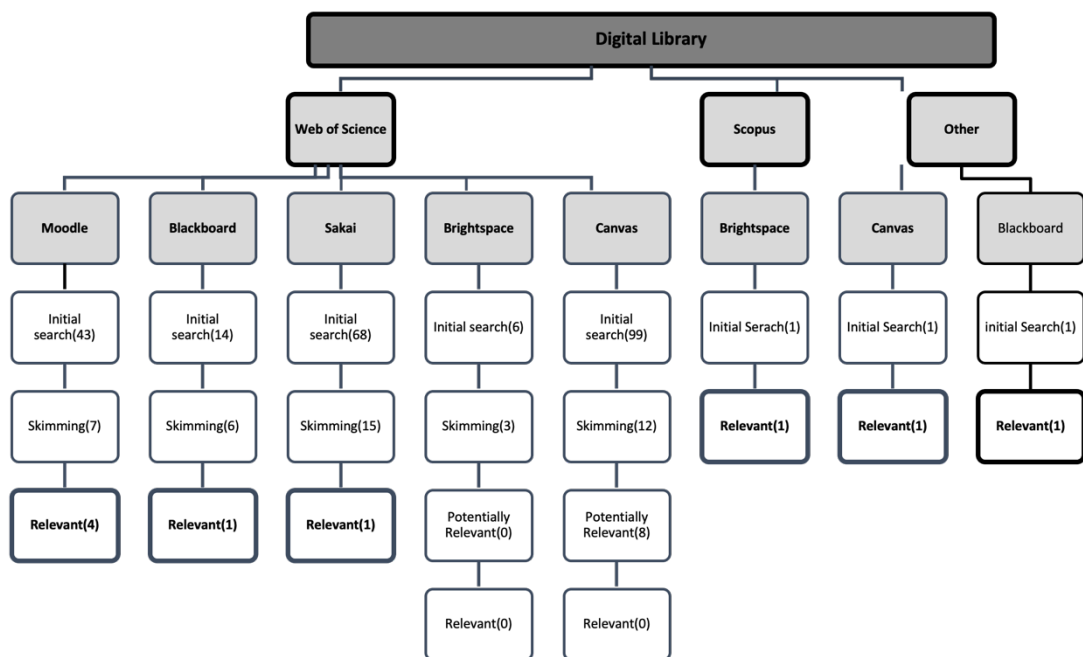


Figure 2. Overview of search results

Table 4. Relevant LMS Learning Path Literature

Learning Management System	Relevant Sources
Blackboard	Smirani et al., 2022 Blackboard, 2022
Brightspace	Liu et al., 2017
Canvas	Chen and Paradiso, 2021
Moodle	Zabolotskikh et al., 2020 Chang et al., 2022 Lumy et al., 2022 Ramos et al., 2021
Sakai	Burgos, 2019

Quantitative meta-analysis

RQ1: Are the implemented learning paths personalised?

Blackboard

Nine universities in South Africa currently use Blackboard (the University of Johannesburg indicated their intentions to switch from Blackboard to Moodle). Walter Sisulu University moved to Moodle in 2021. Overall, the adoption of Blackboard in

Africa has been slow due to its relatively high fees (Al-khresheh, 2022). Blackboard offers several features to students, such as studying independently, asking questions, posting statements, accessing course materials, collaborating with others and receiving immediate feedback for non-complex assessments (Boshielo, 2014). However, Blackboard is more effective for self-motivated students who are sufficiently digitally literate to navigate the LMS (Rahmatullah, 2021). With little effect on student performance, attitude and engagement, Blackboard is seen to have no impact on improving students' acquisition of required skills while providing lecturers with little means to facilitate learning measures (Rahmatullah, 2021).

Although Blackboard has no specific learning path features, it offers several tools that could produce effects that lead to adaptive teaching and learning measures. For example, the Blackboard Predict tool helps students visualise their course performance with projections of future grades. The Predict model includes demographics, financial aid information, past performances, course difficulty, course design and performance of other students. The tool provides analytical data on students' activities to the facilitator, coach, advisor, or tutor, only for students who opt for the tool (Blackboard, 2022). Blackboard automatically prioritises activities such as alerts, announcements, due dates, grades posted, added items, and missed or overdue tasks for students to help them focus, plan and meet deadlines. Work has also been done by Smirani et al. (2022) using Blackboard's "Adaptive Release" tool to set up rules that enable the delivery of personalised student content (Blackboard, 2022). While Blackboard successfully implements personalised learning paths, Smirani et al. (2022) highlighted the limitations of using Blackboard as the only data source when determining personal learning paths.

Brightspace

Brightspace is touted as a platform that "enhance[s] learning through technology at every stage of life" (Simone & Taiwo, 2015). The Brightspace LMS is a flexible solution with easy navigation and a comprehensive grade book. In South Africa, Brightspace is used by the University of Cape Town and the Tshwane University of Technology. In terms of features, Brightspace uses a personal portfolio for storing, organising and sharing items that represent a student's learning journey. In these, students control what goes into that portfolio and who to share it with (Brightspace, 2022). There is also a tool known as SmarterMeasure, a learning readiness indicator that measures the readiness of students based on non-cognitive indicators of success and uses positive reinforcement and helpful resources for feedback (SmarterServices, 2022).

Standard to the LMS is Brightspace LeaP, an adaptive learning tool that creates personalised learning paths (study plans) based on the student's performance on their diagnostic assessment, which is done as an initial assessment (Liu et al., 2017; Brightspace, 2022). Brightspace LeaP creates course content presentations based on common institution-specific or course-specific learning objectives. The learning paths adapt to specific students' needs based on their strengths and weaknesses as they interact with the tool. Based on a diagnostic assessment of the student's performance, personalised learning paths are generated for a particular student. Following the generation of personalised learning paths, a semantic analysis engine is used to align learning outcomes, assessments and content to determine learning objectives for the student. One limitation of LeaP is that it can only perform as well as the content design uploaded by a module's instructors. Still, the answer to the research question is that Brightspace can implement personalised learning paths.

Canvas

Canvas is a commercial cloud-based LMS explicitly designed for universities (Garcia et al., 2020; Instructure, 2022). The University of the Witwatersrand uses Canvas after migrating from the Sakai platform at the end of 2021. The Canvas offering provides typical LMS functionality, including real-time face-to-face communication tools, assessment tools, a speed grader, and a user-friendly interface, giving easy access to coursework (Instructure, 2022). Canvas has basic profile details, course content, course details, level of performance, feedback with annotation, analytics on learning outcomes, intervention analysis, schedules, events and student progress, and attendance data (Instructure, 2022). Canvas has a Student Information Systems (SIS) import feature, which allows the importing of complex data from other external tools. Admins use the feature to create users, accounts, courses, login and enrolments (Instructure, 2022). One criticism levelled at the Canvas LMS is that it lacks non-formal learning features such as self-direction, identity, or passion, as students are hardly given options based on their strengths or limitations (Garcia et al., 2020). Such variability is viewed as a lack of flexibility to cater to diverse learning styles and stifling student development of critical thinking skills (Garcia et al., 2020).

Canvas has a learning path feature called MasteryPaths, which personalises students' learning experience through diagnostics, assessments and targeted content scaffolding based on student performance (Chen & Paradiso, 2021). This feature is available only to students who subscribe to the tool (Instructure, 2022). MasteryPaths is dependent on predefined course content developed by the course instructors. The diagnostic assessment is a knowledge check determining each student's starting point, with students classified based on their performance and given tests based on their level of knowledge. The process is repeated until a student performs well enough to move to a higher level, helping students record their attainment of the required high performance and proving that they have mastered a particular subject. On Canvas, instructors can configure differentiated learning content based on a student's performance through MasteryPaths (Chen & Paradiso, 2021). Due to this limitation, MasteryPaths is not entirely personal. Therefore, we cannot conclude that Canvas can implement personalised learning paths.

Moodle

Moodle is the most popular LMS in South Africa, used by fifteen universities. Moodle is an integrated solution for creating personalised learning environments to provide a comprehensive set of features that enable instructors and students to communicate with each other effectively, complete assessments, obtain course feedback, and partake in quizzes (Hasan et al., 2019; Bessadok et al., 2021).

Zabolotskikh et al. (2020) developed a custom plugin called "University CourseAssist" to create learning paths by utilising the student's learning styles and levels in English based on assessment tests. The plugin was specifically used for teaching English grammar courses. It highlighted the limitation that considering learning style and English proficiency does not cater to students who lack motivation and struggle with monotonous work. From this, the researchers recommended that future research considerations include improving meta-cognitive skills and enhancing students' self-regulation and development.

In another study, Chang et al. (2022) researched providing personalised learning on demand for a programming course. The research recommended a personalised learning map based on the student's background and needs. Using Bayesian classification, the study used a mid-term assessment test to understand the student's learning status to generate personalised learning. Using the final exam mark as the post-mark score to evaluate personalised learning, the study highlighted that Moodle's design (with its restricted user data) limited its effectiveness in syncing user data.

Further research conducted by Lumy et al. (2022) employed the Felder-Silverman learning style model (FSLSM) to create learning paths evaluated using hypothesis testing. The authors derive learning paths through a nine-step flow that used Moodle's log data to identify a suitable learning path for that particular student (Lumy et al., 2022). The study revealed that learners who follow the learning paths perform better. However, the researchers note that the learning paths are not yet optimised.

Lastly, in an experiment with visual learning paths using the database of an LMS in a natural environment, Ramos et al. (2021) used computer science, physics, and electrical engineering students to prove that learning paths can help analyse behaviour patterns. This study used students' action history from the database records on the LMS to inform the generation of learning paths. This work presented the LPGraph plugin for Moodle that shows how the students often interacted with the course content. That view is then used with a proposed M-Cluster model to suggest groups for students who perform the same activities using the K-Means algorithm. Ramos et al. (2021) suggested future work by promoting learning paths to improve learner performance. The LPGraph limits the adaptability of learning paths because it is a real-time tool that does not save the findings for the future (Ramos et al., 2021). Based on the four studies reviewed for Moodle, we conclude that Moodle can implement personalised learning paths.

Sakai

Sakai is an open-source solution with no specific developer, leading to different data representations (Burgos, 2019). In South Africa, Sakai is used by the University of the Western Cape and North-West University. Also, it was previously used by the University of Cape Town, which migrated to Brightspace in 2022, and the University of Witwatersrand, which migrated to Canvas in 2021. Sakai seeks to improve learning effectiveness through collaborative learning, multimedia course content, online assessment, course management, and individual online learning (Tagoe & Cole, 2020). It also seeks to improve information acquisition skills and reduce student withdrawals and absenteeism (Dube & Scott, 2014).

Using the Sakai platform datasets, Burgos (2019) predicted students' performance and behaviour based on online activities. The research classified students according to their learning styles while looking at additional data on students' profiles, courses, grade books, assignments, quizzes, forums, and activity logs to define the user model. A self-report MBTI-Briggs Type Indicator questionnaire was used to analyse students' profiles. Burgos's (2019) model only identifies students' cognitive profile and leaves it to the instructors to formulate the course material that fits their cognitive profile. One shortcoming of Sakai, which impacts the monitoring of student activity, is how it functions on an HTTPS request or reply model, making it difficult to determine the time spent on activities (Burgos, 2019). Since there is manual intervention from the instructor

to formulate the course material, there is no proof that Sakai can implement personalised learning paths.

The meta-analysis of the LMSs reveals that, while other LMSs do not necessarily have specific learning path features, their environments are conducive to developing additional tools that could generate personalised learning paths using the information provided by the LMS. Moodle, in particular, exhibited the highest number of such implementations. The review concurs with Kitchenham and Charters, (2007) that the ways personalised learning is designed can lead to students' confusion and frustration. To answer this research question, the authors note that all the reviewed LMSs can implement personalised learning paths. Although, Canvas and Sakai did not have sufficient data to prove they can implement personalised learning paths.

QR 2: How adaptive are the learning paths to meet student's specific needs?

Personalised and adaptive learning is the personalisation of learning according to the student's unique combination of attitude, browsing behaviour, motivation, performance, learning styles, social background, preferences, or integration with AI, Machine Learning (ML) or data analytics (Kabudi, 2021; Vanithaa & Krishnanb, 2019; Lumy, Sajimon, & Biju, 2022; Palanivel & Kuppaswami, 2014; Chen C.-M. , 2008). The success of any personalised LMS relies heavily on its design being able to accommodate constant adjustments of the LMS's behaviour as the student's needs change (Bunting et al., 2021).

Based on the characteristics mentioned earlier of personalisation, the learning paths on each LMS are evaluated in terms of unique attributes, constant adjustment (adaptability) and integration with AI, ML or data analytics. Previous research mentioned that personalised learning lacks consideration of the diversity of students' backgrounds, resource limitations, and various learning abilities (Kabudi, 2021). This research question evaluates whether the implemented learning paths on the LMSs solve these gaps. *Table 1* compares the five LMSs to show the unique attributes, components used to adapt, and the list of integrations used, if any.

As shown in Table 3, the learning paths developed on Blackboard generate and visualise future learning goals using data analytics of past students' performance. Though Blackboard has access to other data, such as financial aid, it only visualises it but does not use it to adapt the learning paths. Meanwhile, Brightspace uses student performance, course-specific, and learning objectives as unique attributes, then applies semantic analysis to a diagnostic assessment to generate learning paths. Likewise, Canvas's learning paths use past performance results of a diagnostic assessment to generate learning paths but have no AI, ML or Big Data integration. Meanwhile, Moodle uses learning styles, assignments, exams and test performance, learning status, LMS logs, behaviour patterns, and action history. The review on Moodle shows that Moodle can be adaptive by applying K-means and M-cluster to visual learning paths based on behaviour patterns, action history and Moodle's database, even though the learning path's adaptability is limited because it is real-time. The review on Moodle highlights a need to include meta-cognitive skills as part of the attributes used to build the learning paths because there is limited data, and using data from Moodle logs leads to unoptimized learning paths. Lastly, Sakai creates learning paths from a user model built from students' online activities, learning styles, course grades, assignments, quizzes, activity logs, and forums. Sakai's user model is analysed with an MBTI-Briggs type indicator

questionnaire, then used to predict user performance, which can be applied to build learning paths by instructors. The limitation is that this tool does not automatically create the learning paths and thus is not adaptable to meet students' specific needs. We can further conclude that Blackboard, Canvas, Brightspace and Sakai are not adaptive to students' needs. They mostly use course attributes to generate learning paths, not personal student-unique attributes. However, Moodle has the most unique attributes, and adaptive components required for personalised learning paths.

Table 5:LMS Learning Paths Comparison

Learning Management System	Unique attributes	Adaptability	Integration with AI, ML or Data Analytics
Blackboard	Past course performance, future goals, financial aid	Projection of future goal	Data Analytics
Brightspace	Student performance, course-specific, learning objective	It uses diagnostic assessment and, thus, is not adaptive	Semantic analytics
Canvas	Level of knowledge, student course performance, course content	It uses diagnostic assessments and, therefore, is not adaptive	None mentioned
Moodle	Learning styles, assignments, exams and test performance , learning status, LMS logs, behaviour pattern, action history	Adaptive per learning status, Adapts as the behaviour changes Limited adaptability	Bayesian classification , M-cluster and K-means
Sakai	Online activities, learning styles, course grades, assignments, quizzes, activity logs, questionnaire	Only cognitive profile no adaptability	None mentioned

RQ3: Does the LMS have data valuable to build learning paths beneficial to students?

To build personalised learning paths that are helpful to the students, the LMS must have the data or access to retrieve the data required to construct an adaptive, personalised learning path (Matarirano et al., 2021; Le et al., 2009; Bessadok et al., 2021; Mpungose et al., 2022). As other research has noted, the data limitations and lack of a data-informed decision-making culture hinder the effectiveness of personalised learning (Li & Wong, 2020). The review of the LMSs indicates that none of the five LMS systems uses data from the student's profile beyond the course structure or the activities performed on the LMS. The data is mainly on the student's learning styles, activities performed on the LMS and course content data. No research focuses on the data derived from the social profile of the students, which can include social life, attitude, computer self-efficacy, financial background, or overall well-being.

Conclusion

As part of a study to establish a new e-learning recommendation model to enhance LMSs to offer effective personalised learning paths to accommodate diverse student learning, this research examined the current state of popular LMSs used at public universities in South Africa. It was identified that five LMS platforms dominated the space, namely Moodle, Blackboard, Sakai, Canvas, and Brightspace. The LMSs featured some

personalisation concerning the design of personalised learning paths, and most integrate some type of AI, ML, or data analysis. However, they all demonstrated gaps when the student data collected were measured against the attributes required for a personalised learning path. This suggests that the data collected within the LMS alone is insufficient for informed learning and teaching customisation decisions. Specifically, the LMSs in question mainly focused on learning paths that involved knowledge of course content or performance on predefined diagnostic assignments, preceding the teaching of critical thinking skills, an essential element of success. By overlooking student data beyond their interaction in a particular module, the LMSs overlook a student's social background and overall performance. Doing so ignores the rich diversity of students' backgrounds and departs from the human-centric focus that Industry 5.0 advocates for. A successful foray into personalised learning paths would thus require consideration of other student data sources. Ultimately, an LMS must work with other data the university may collect to produce a suitably comprehensive custom experience with student success in mind. For university decision-makers who may be tasked with investigating a new LMS platform to switch to, this work is anticipated to partially assist when considering its suitability for personalised learning paths.

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Exploring the heart of peer review of teaching: A qualitative study in a private higher education institution

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Abstract

This qualitative study explored the experiences and reflections of lecturers and reviewers who participated in a peer review of teaching practice in a private higher education institution in South Africa. A peer review of teaching is a supportive process in which a lecturer's teaching effectiveness is evaluated by a peer who provides feedback towards improved teaching practice. A social constructivist lens that places dialogical relationships as central to learning was used as the theoretical starting point to explore the dynamics of the relationships between lecturers and their peer reviewers. Eight lecturers and eight reviewers (who had been paired) were individually interviewed, followed by two focus group interviews with the lecturers and reviewers respectively. Data were collected using Microsoft Teams technology in lieu of face-to-face collection and analysed using a thematic approach. Findings demonstrate that whilst the intention of the current peer review process at the institution is to be a collaborative, formative process committed to the development of professional practice, the data from the study highlight that the intersubjective nature of the relationship and provision for dialogue around reviewer feedback are significant determinants in the peer review process being experienced as valuable. Aligned with relational assessment practices which are gaining momentum in higher education, change is needed for the practice of peer reviewing to have a sustained effect on lecturers' professional development.

Keywords: peer review of teaching, dialogical relationships, professional development, social constructivism, online qualitative data collection.

Context

It is widely recognised that peer review of teaching enhances the professional development of lecturers (Centre for Teaching Support and Innovation, 2017). Peer review is typically an observational process "for the purposes of exploring the learning and teaching process and environment and where this observation leads on to reflection and discussion, with the underpinning long-term aim of improving students' learning" (Bennett & Barp, 2008, p. 559). However, it extends beyond mere observation and aims to improve teaching practice through a structured, reciprocal, and collaborative process, involving feedback from the reviewer to the lecturer (Bovill & Cairns, 2014; Georgiou et al., 2018; Hendry & Oliver, 2012; Volchenkova, 2016).

This study examined the experiences and reflections of lecturers and reviewers who participated in peer review practices at a private higher education institution (Phei) in South Africa. At least once a year, a teaching and learning specialist at the various campuses performs the role of peer reviewer and is partnered with a lecturer to design a learning experience for students which is then evaluated by the reviewer. A teaching observation (lecture) or teaching artefact (material) may be selected for analysis and feedback. This is a formalised, three-phased process where: i) in the initial phase lecturers engage with their reviewers to collaborate and discuss the learning design; ii) the "doing" part where the learning design or artefact is put into practice and observed or analysed;

iii) the resolution of the process, where what is hoped to be constructive and actionable feedback, is provided (Phei, 2018). This internal peer review process has evolved over the years from its inception at the institution in 2006, to a more collaborative approach introduced in 2018. The outcome is largely focused on lecturer development and improvement of teaching practice, with its effectiveness reliant on lecturers' reflection and learning in relation to input and feedback from the reviewer. It is expected that the reviewer's input will be meaningful to the lecturer and will form some basis for the latter's professional development.

Literature review

A myriad of researchers in the field of higher education believe peer reviews to be beneficial and helpful to teachers/lecturers (Esterhazy, De Lange, Bastiansen & Wittek, 2021; Georgiou et al., 2018; Gosling, 2002; Hendry & Oliver, 2012; Woodman & Parappilly, 2019; Volchenkova, 2016; Zeng, 2020).

The literature reveals that quality feedback is essential for the professional development of teaching practice but the responsibility for providing quality feedback primarily falls on the reviewer, resulting in a one-sided approach (Bovill & Cairns, 2014; Blackmore, 2005). Peers who serve as reviewers are typically experts in teaching and learning or in their respective disciplines. However positive outcomes were reported by Woodman and Parappilly (2019) regarding peer review of teaching among early-career academics. Gosling (2002) suggests that the positioning of a 'peer' as a more senior role may even undermine the relationship between reviewer and lecturer, especially if the lecturer feels vulnerable within the relationship. Furthermore, the role of the reviewer in the peer review process raises questions about objectivity and the qualifications to judge a peer's teaching practice (Cosh, 2002; Hendry & Oliver, 2012; McCleod et al., 2013). Blackmore (2005) found that reviewers in her study were hesitant to provide negative comments out of concern for undermining the lecturer's confidence, while Esterhazy et al. (2021) stressed the importance of trust in the reviewer-lecturer relationship to facilitate honest and potentially challenging conversations. There is a need to further explore the dynamics of the reviewer-lecturer relationship and the impact of feedback interpretation and discussion (Esterhazy et al., 2021). Additionally, barriers such as anxiety, time constraints, and dissatisfaction with feedback provided hinder the effectiveness of peer reviews (Blackmore, 2005; Bovill & Cairns, 2014; Zeng, 2020).

The research shows that when the purpose of peer review is developmental in nature and is not linked to any punitive or putative measures, educators are more willing and enthusiastic about participating (Bennett & Barp, 2008). Torres et al. (2017) report that value is gained when peer reviews foster an improvement of practice over a demonstration of practice. Using a multi-disciplinary approach in contrast to some of the more commonly advocated approaches showed a benefit in that lecturers shifted from what they were teaching to how they were teaching – so the focus became the pedagogy and the resultant reflection (Torres et al., 2017).

Learning opportunities can arise for both lecturers and reviewers through the peer review process. The observation aspect of a peer review can be beneficial for the reviewer's own development (Hendry & Oliver, 2012). This is supported by Tenenbergs's (2016) theoretical model for observation which suggests that the observer's learning occurs through a dual process: identifying and recognising similar issues that they might also encounter, thereby potentially discovering new solutions through the act of observing

a peer. It is worth noting that the existing literature tends to focus primarily on the reviewer's learning through observation, rather than examining the potential learning that can occur through the dynamic relationship, dialogue, and feedback between the reviewer and the lecturer.

A relational perspective thus offers valuable insights for peer review. A social constructivist approach to learning acknowledges the significant impact that a relationship makes on the co-construction of meaning. The parties involved enter into a mutually beneficial and valuable dialogue about their learning and these meaningful relationships flatten the power differential since all participants are pursuant of the same goals (Morrison & Chorba, 2015). Extending the discourse on relational practices in education, recent research on evaluation focuses on assessment of learners as being dialogical and relational. Gill and Gergen (2020) highlight relational processes as fundamental for assessment in education. While they are primarily concerned with assessment of learners and not assessment of lecturers, some insights offered can be extrapolated for peer evaluation of lecturers teaching in schools as well as higher educational institutions. The authors suggest that “interest and care for learning tend to derive from relationships. These relationships are built on the co-creation of values through a dialogue” (Gill & Gergen, 2020, p. 404).

Overall, these perspectives highlight the significance of trust, dialogue, flexibility, and a shared commitment to reciprocal growth and learning in fostering positive and productive collegial relationships.

Theoretical framework

The constructivist learning theory, and more specifically, the social constructivist theory developed by Vygotsky (1978, 1997), is a useful theoretical framework for this study. What unifies all the constructivist learning theorists' positions is a fundamental belief that humans construct knowledge and meaning from their experiences, which are formed in contexts of social interaction (Holzman, 2009; Amineh & Asl, 2015; Akpan, Igwe, Mpamah & Okoro, 2020). When viewed from a higher education perspective, collaborative learning environments involving discussion, sharing of knowledge and interaction demonstrate social constructivism (Akpan et al, 2020). Amineh and Asl (2015) define social constructivism as a theory of knowledge and communication that examines the knowledge and understandings of the world that are developed jointly by individuals.

As applied to professional development and the peer review process in encouraging such development, a social constructivist approach implies that the insights gained from the process arise from active meaning-making in a social context (in this case the context of peer review). Holzman (2020) emphasises that Vygotsky “understood development (qualitative transformation) as a collective accomplishment” (p. 176). That is, he understood development as a form of “cooperation or cooperative activity”, and a “collective form of working together” (Vygotsky, 2004, p. 202). Holzman (2020) remarks that “in more contemporary social constructionist terms, development grows from responsiveness and relationality” (p. 176). Through peer review, lecturers should ideally be seeking to improve the way they teach students to learn, through a partnership with the reviewer. Lecturers need to reflect on their practice in order to apply these ideas to their work (Bovill & Cairns, 2014; Georgiou et al., 2018; Hendry & Oliver, 2012; Volchenkova, 2016; Palinscar, 1998; Shabani, Khatib & Ebadi, 2010). The process is thus

meant to be one of reflection, collaboration, co-construction, feedback and reflection again.

Furthermore, Triantafyllou (2022) supports Vygotsky's stance that learning is not an isolated process and must take into account an individual's personal context. Triantafyllou highlights the interdependence of learning and personal growth, highlighting the significance of everyday encounters in shaping one's perception of the world. According to Triantafyllou (2022), the connections individuals form are pivotal in the construction of knowledge, as they offer chances for discussions, negotiation and the sharing of ideas

The research problem

One of the major aims of a peer review process in higher education is to support lecturer development through feedback provided by a reviewer. Lecturers are assumed to learn and grow through the process of peer review by being observed, evaluated, and ultimately 'assessed'. However, not all peer reviews are guaranteed to result in learning on the part of the lecturer. Despite the obvious benefits of a peer review programme – as presumably “easy to implement, scalable, applicable [with] increased collegiality” (Georgiou et al., 2018, p. 190) – the processes are challenging to manage over time because they can cause an intimidating, evaluative environment that is not conducive to growth and reflection. When viewed through a social constructivist lens, peer reviews should be approached as a context for collaborative, dialogic and relational learning. The literature lacks sufficient exploration of the relational dynamics between the reviewer and the lecturer, as well as how these dynamics influence the effectiveness and value of the peer review process. Furthermore, there is limited investigation into whether learning can occur on both sides through the dialogue and feedback exchanged during the peer review.

The research questions

What are the important dynamics in the relationships between lecturers and reviewers in a private higher education institute?

Several sub questions can be derived from this, namely:

- 1) How do the perceived power differentials between lecturer and reviewer and any other factors affect the dialogical relationship?
- 2) What is the quality of the dialogue (as experienced) and how does it contribute towards learning?
- 3) How can lecturers and reviewers both respond to feedback in a way that leads to learning being experienced by both parties and how might this be applicable in the professional development context?

Methodology

This qualitative study is guided by an interpretivist paradigm and a constructivist approach, which aims to explore the participants' perceptions and experiences and co-create meanings (Lincoln and Guba, 1985). The population of my study comprised full-time and part-time lecturers across multiple campuses of the chosen private higher education institute in South Africa's major centres. A purposive sampling method was employed due to varying accessibility, interest, and expertise among lecturers and reviewers as well as complexity, due to the requirement for paired work on campuses. The final sample consisted of 16 participants: eight lecturers and eight reviewers. Participants were selected nationally from Johannesburg (four), Pretoria (four), Cape Town (four), Port Elizabeth (two), and Durban (two). They represented diverse

educational, discipline, and industry backgrounds, including academic, teaching and learning, creative, and business expertise.

Data were collected through individual interviews and focus groups conducted online through the Microsoft Teams technology. This method of connection offered a “realistic and comparable alternative” (Kite & Phongsavan, 2017, p. 6) to face-to-face interviews and focus groups. Falter, Arenas, Maples, Smith, Lamb, Anderson, Uzzell, Jacobs, Cason, Griffis, Polzin and Wafa (2022) point to the use of media such as Zoom for focus group sessions and CohenMiller and Boivin (2022) likewise suggest the relevance of the move to online data collection especially in the light of the Covid-19 era. We were all used to conducting conversations online and these interviews were no different. Moreover, the sample of participants were spread geographically and conducting all the interviews online meant that I was able (cost-wise) to include four geographical areas in the research. Likewise, the same holds for the focus groups, where they shared experiences.

Notably, having the cameras on in all interviews and focus groups allowed me to see facial expressions and collect both verbal and non-verbal data (Irani, 2019), and this mode most closely replicated the face-to-face interview and focus group environment where participants can see one another. Another advantage was that participants may have been more relaxed and comfortable when interviewed in familiar surroundings (Irani, 2019). Interview and focus group material (along with the member checking process) was analysed using thematic analysis.

Discussion

My analysis revealed several key themes that emerged from the data, capturing the experiences and insights by both the lecturers and the reviewers. The themes are presented in a tabular format below.

Table 1: Themes that emerged from the data

Themes that emerged from data generated from the lecturers

Theme 1: Important Dynamics in the Peer Review Relationship

Nervousness and vulnerability • The need for mentorship • Openness to improvement • Power differentials • Perceived reviewer bias • The nature of the relationship

Theme 2: Factors that Affect the Peer Review Relationship

Positioning of the peer review • Scheduling versus planning the peer review • The reviewer as ‘expert’ • The perception of the peer review as an assessment • The anticipation of student behaviour

Theme 3: The Relationship Between Dialogue and Learning

• An ongoing dialogue • Limited dialogue, limited learning • Dialogue and learning within communities

Theme 4: Receiving and Responding to Feedback

• Criteria-framed feedback • Student feedback considered • One-sided feedback • Dialogical feedback • Remedial action • Self-efficacy

Themes that emerged from data generated from the reviewers

Theme 1: Important Dynamics in the Relationship

The essential building blocks of a relationship: Honesty and lack of ego; Trust; Authenticity and enthusiasm; Objectivity/Open-mindedness and compassion; Sharing of ideas and collaboration • Power differentials in the relationship

Theme 2: Approaches Within the Relationships

Pairing people up carefully and intentionally • Putting the lecturer at ease • Positioning the purpose of the review • Shifting to dialogue • The focus of the review • Undefined general observations • Specific areas of focus in content and pedagogy • Focusing on building student skills

Theme 3: Value to Lecturer and Quality of the Dialogue

• Providing mentorship • How to create value • The role of dialogue in creating value • Reassurance for the lecturer

Theme 4: Packaging the Feedback

• Paperwork and criteria • Student-centred discussions • ‘Sandwich’ feedback • Triangulating feedback with other teaching elements • Avoiding giving feedback • Simultaneous feedback • Closing the loop

Theme 5: Learning for the Reviewer

Was the review a learning experience for them? • Communities of practice

The research questions revisited

To provide a comprehensive and contextualised discussion, it is essential to revisit the research questions that guided this study. By doing so, I aim to situate the ensuing discussion within the specific areas of inquiry and present the findings in relation to the initial research objectives.

What are the important dynamics in the relationships between lecturers and reviewers?

As suggested by Motschnig-Pitrik and Barrett-Lennard (2010), relationships within specific social contexts of interaction present as new relationships - the peer review relationship is a completely new entity with a distinct goal. Just like in any form of communication between parties, lecturers and reviewers do not come together in a vacuum; there is always a context. In addition, they are each subjective and bring this subjectivity to their peer review relationship. Intersubjectivity affects the relationship and can be nurtured with trust and open-mindedness on both sides. But the dynamics of the relationship can also result in the process not feeling valuable to either party. Important dynamics were identified by the lecturers as nervousness and vulnerability, one lecturer said *“I’m always so stressed...I think I could lecture for 10 years and would still be stressed”*. Other dynamics were openness to improvement, power differentials (discussed in more detail below) and perceived bias of the reviewer. The reviewers felt there were a few important building blocks in the relationship that needed to be present, namely: honesty, lack of ego, trust, authenticity and enthusiasm, open-mindedness and compassion, sharing and collaboration and a recognition of diverse relational needs. One reviewer mentioned *“It is a trust relationship that we need to build. The lecturer contributes so much value from a practice side. This is a relationship that we need to nurture”*.

How do perceived power differentials between lecturer and reviewer and any other factors affect the dialogical relationship?

Power differentials do exist within the various relationships but not for the same reasons. The effect on the dialogical relationship is very much dependent on the type of power differential. This becomes a negative factor when one person does not interact or engage openly because of their fear arising from the power imbalance. It was quite evident that the part-time lecturers felt more insecure, and this contributed to a perceived power differential between management and full-time employees and part-time lecturers. I found that this topic came up frequently with the lecturers and yet it was absent from the discussions I had with full-time employees. This power differential created by a contextual, contractual condition, created a perception among the lecturers which affected the relationships they had with their reviewers. San Pedro and Kinloch (2017) recognise that perceived power imbalances can negatively affect positive relational dynamics in the workplace. Another prevalent power differential theme was identified with new lecturers and their reviewers who became their mentors. In these instances, the power imbalance was acknowledged and even invited, as the lecturers were reliant on the guidance and mentorship provided by the reviewer. Thus, the power imbalance was not perceived in a negative way. All the new or novice lecturers wanted the guidance of a more experienced and skilled person to mentor them and act as a role model, *“As a newbie, I welcome the peer review. I always say that the presence of my peer is an opportunity to really improve my teaching and learning methods... I want something that is authentic and honest”*.

Another significant factor that appeared to affect the relationship was the sense that the peer review instrument feels like an assessment. Several of the lecturers believed it was linked to their re-appointment or rate increase, the connotation of the word 'review' was discussed and the criteria were felt to be a measurement of their performance. This sentiment was echoed by some reviewers who commented how the criteria were "rubric-like". Another reviewer asserted that the criteria are too prescriptive and "*forces one to look for the elements that match the criteria instead of being a flexible guideline that can be completed afterwards*". I argue that until the process is no longer seen as an assessment instrument, it will be challenging to foster fruitful and positive relational dynamics and encourage authentic learning.

What is the quality of the dialogue and how does it contribute towards learning?

Through my analysis of the data, I was able to establish a strong link between the quantity and quality of the dialogue and perceived value and learning. Lecturers who reported experiencing a good quality dialogue also felt they had gained considerably from the process, "*It was creative and productive and it continues in my thoughts which makes me look forward to my next peer review*". Many reviewers felt strongly that the conversation or dialogue was the most meaningful part of the entire experience. It was suggested by some that the dialogue should really begin before the process and be focused on sharing meaning as a precursor to co-construction. One reviewer felt this approach mediated the lecturer's defensiveness, "*I emphasised that we should put our minds together and share some ideas... let's talk about what we want out of our graduates so that we take the focus off the lecturer. The focus should not be that I'm checking to see that you're doing your job. I know you are doing your job*". The reviewers strongly indicated that dialogue needed to be distinguished from the peer review instrument to allow for openness and shared meaning to develop. I discovered that a shared construct and, therefore, a robust dialogue, can create the foundations for a very fruitful relationship, but negative relational dynamics can get in the way of a good dialogical experience. It was also apparent that when dialogue was absent or limited, there was limited learning and questionable value. Relational learning recognises the significance a relationship has on the co-construction of meaning. The relationship itself becomes central to the learning and the parties involved feel that they are entering a mutually beneficial and valuable dialogue about their learning (Morrison & Chorba, 2015).

How can lecturers and reviewers both respond to feedback in a way that leads to learning experienced by both parties and how might this be applicable in the professional development context?

Currently the freedom and space to respond to feedback is determined by the quality of the dialogue at the point of feedback and the people involved. Some lecturers felt confident enough to question feedback and, in some cases, challenge it. Likewise, some reviewers were very open to lecturers doing this and had robust discussions as a result. Currently, the feedback session is based on the premise that a reviewer should be providing direction to the lecturer in order to improve their teaching practice. Criteria-framed feedback was a source of conflicting opinions among the lecturers and reviewers. Lecturers who were new to the process, as well as experienced reviewers, who partnered with new lecturers, did not object to providing criteria-framed feedback. However, with more experienced lecturers and peer review relationships that sought depth and freedom, the criteria were seen as prescriptive and limiting to the dialogue. One experienced reviewer completely ignored the criteria for the feedback session but reported having gained maximum value out of the session as did the lecturer she was paired with, "*I think*

(criteria-framed feedback) encourages us to be anxious about trying to achieve one particular model of teaching and learning". With new lecturers, the feedback session gave a great sense of self-efficacy. However, a few lecturers felt that if the feedback was not meaningful, they would just ignore it.

In its current format, there is no formal way for lecturers to respond to feedback provided by their reviewers and the data shows that many reviewers are unsure how they might respond to feedback on their feedback. Due to the way the process is currently implemented, the feedback part is largely one-sided and led by the reviewer. However, an opportunity and a willingness to learn on both sides exists if the process is re-framed within a relational construct. One pair of lecturer/reviewer in the study successfully achieved this relational partnership. The reviewer reflected on that feedback session, noting *"it wasn't about the activity, it was about what we both learned from that activity about our pedagogies, about our students"*.

Reflections

Whilst the intention of the current peer review process is to be a collaborative, formative process committed to the development of professional practice, the data from the study demonstrates that relational dynamics and dialogue are significant determinants in the process being experienced as valuable. It is, therefore, important to recognise the intersubjective nature of the peer review relationship and the contextual factors that affect it. Intersubjectivity can be nurtured with open-mindedness on the side of both parties and positive relational dynamics can indeed be cultivated (San Pedro & Kinloch, 2017; Lee et al., 2020).

Implications of a relational perspective for peer review extend to mentoring and co-teaching relationships. Jeannin and Sing (2018) reflect on a co-teaching experience driven by a shared goal, reciprocal accountability, and trust. The authors reported on an ongoing dialogue throughout the co-teaching relationship that resulted in debate, questioning and challenging (Jeannin & Sing, 2018). Cordie et al. (2020) propose a model of co-teaching as mentoring, emphasising reciprocal communication and collaboration. This model recognises that both parties bring different experiences and contexts to the relationship. The mentors themselves can grow professionally and develop a scholarship of teaching and learning through their relationship with the mentee (Cordie et al., 2020).

Co-actualisation and fostering positive workplace relationships through relational spaces and interaction scripts are additional considerations for enhancing the peer review process (Motschnig-Pitrik & Barrett-Lennard, 2010; Lee et al., 2020). Co-actualisation is presented as a construct to view meaningful, fruitful and mutually enhancing relationships. This type of relationship can emerge when two people acknowledge that the outcome of their dialogue and collaborative discussion will be better and more robust than if they grappled with the topic individually (Motschnig-Pitrik & Barrett-Lennard, 2010).

Fostering positive relationships in the workplace involves dimensions of respect, openness, and connectedness (San Pedro & Kinloch, 2017). One mechanism suggested by Lee, Mazmanian & Perlow (2020, p. 8) to encourage respect, openness and connectedness is to create "relational spaces". These are not physical spaces, but "containers" or "vessels" for individuals to come together in a safe space to collaborate, speak openly and honestly, to share and exchange ideas, experiment and feel included

(Lee et al., 2020). Supportive to these relational spaces is the construct of “interaction scripts” as put forward by the authors (Lee et al., 2020, p. 10). Scripts promote a shared understanding of how to “act and behave” and reinforce desired approaches and norms within the interactions between people (San Pedro & Kinloch, 2017).

Recommendations

1. Re-framing the ‘one-size-fits-all’ peer review into more tailored relational experiences with mechanisms in place to foster positive relational dynamics, implement two-way feedback (Gill & Gergen, 2020) and provide opportunities for both parties to learn and grow. The process is thus reframed into a relational model for professional development of teaching practice.
2. The process of placing reviewers with lecturers should be undertaken in such a way that it acknowledges the central role of relational dynamics to the success of the peer review. Training focused on a shared understanding of the nature and effect of encouraging intersubjectivity is recommended.
3. I recommend re-positioning the process within a “holding space” (Lee et al., 2020, p. 8): a safe teaching and learning space where lecturers and reviewers come together to share, experiment, talk about their fears and problem-solve, and can do this without the anxiety of being judged, contracts not being renewed, or punitive measures being put in place.
4. More practice-based learning opportunities for both parties should be identified (Boud & Brew, 2013) so that the perception of the peer review as an assessment instrument is refocused to a practice-based learning opportunity. Both parties must feel that they are gaining something for themselves through participating in a peer review even if that relationship is more of a mentorship (which lends itself to the reviewer as the leader).
5. Consideration should be given to re-naming the process to remove the connotation that the word ‘review’ brings to the experience.
6. I suggest removing the (rigid) criteria and developing instead “interaction scripts” that foster dialogue within these relationships (as advised by Lee et al., 2020, p. 10). I recommend scripts that are developed and tailored to each unique setting for the peer review. These can serve as ‘conversation starters’, but also create parameters for minimum standards and best practice. These would replace the prescriptive criteria and allow for an organic dialogue to develop through the relationship. A feedback script using a questioning technique should be considered as a mechanism for shared feedback as opposed to one-way feedback.
7. I recommend that further learning and an extended dialogue should be encouraged by identifying academic output opportunities (Motschnig-Pitrik & Barrett-Lennard, 2010) and encouraging community of practice. I recommend bringing the peer review process in its new relational form into more varied teaching practice areas, more shared spaces and using the experience to leverage other academic practices, such as research.
8. Further research should be undertaken to better understand the relational dynamics between full-time employees and contracted part-time individuals. The sensitivities and vulnerabilities that exist due to the part-time lecturing model found in many private higher education institutions should be explored, with the aim of fostering more positive relationships and retaining key individuals who bring with them a wealth of industry and discipline-specific expertise.

The final word

The heart of peer review of teaching lies in the fostering of meaningful dialogue, mutual reflection and professional growth of both lecturers and reviewers. However, change is needed for the practice of peer reviewing to have sustained value and effect on professional development. Whilst this study was limited to one private higher education institution, its significance in enhancing teaching practice development is substantial. Practical solutions include reframing peer review of teaching to more tailored relational experiences, focusing on shared understanding and collaborative, judgement-free dialogue; as well as replacing rigid criteria with customised interaction scripts which can transform it into a practice-based learning opportunity for both parties, with academic output potential. Learning and growth, as viewed through a social constructivist theoretical lens, is seen as interconnected, interdependent and intersubjective. This study highlights an urgent imperative to establish a more dialogical, relational and constructivist platform for peer review of teaching. Such a platform would serve as a pathway to fostering productive relationships and the exchange of ideas, and ultimately contribute to the co-construction of teaching practice knowledge in higher education.

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The impact of computing technology on the future of Industrial Engineering: A South African perceptive in the Universities of Technology

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Abstract

In today's economy, industrial engineering (IE) must respond to the changing needs of manufacturing, information, and service industry in South Africa in order to meet market demands. The evolution of IE education is necessary for the profession to remain competitive in the global trade. The ability of IE to cope with managing complex systems met in specific technological problems needs to be addressed in educating industrial engineers. The future of IE can be summarized by the increase in the implementation of multidisciplinary application of computational IE modelling and simulation tools to real-life situations. The focus of the paper is on the impact of these computational tools on the future of IE and the requisite response of engineering education to this new and dynamic environment. A preliminary investigation based on a qualitative research approach suggests that engineering curriculum for universities of technology (UOT) cannot remain unresponsive to the challenges of globalization and diversity, world culture, and ethics. The curriculum must provide a foundation necessary for the profession to remain competitive. Findings of this research will be complemented with a recommendation that will present critical outcomes needed in IE curricula to embrace the impact of technology.

Keywords: Engineering, Education, Computer, Technology, System

Introduction

It was neoclassical economists that brought technological progress to the forefront as an explanatory factor of economic growth. To allow for long-run growth in GDP per capita, an exogenous term, labelled "technological progress" was added, which is assumed to reflect advances in the use and application of technology. Advances in computing, information and communication technology have dramatically and permanently altered the landscape that constitutes what industrial engineers (IEs) call work. This landscape is not only a reality within which IEs will work but is also the reality that IEs will work with.

UoT graduate industrial engineers will experience a high-technology work environment which will be their working environment and the system for developing solutions to the daily engineering problem. The method of problem-solving engineering problems and the system within which future IEs will function is characterized by high-technology systems. The emphasis of many companies is no longer how engineers learn new production and design techniques, instead everyone wants to know how quickly they can perform them (Tamim et al., 2011).

The South African Institute of Industrial Engineers (SAIIE) describes industrial engineering as being concerned with the design, improvement, and installation of integrated systems of men, materials, and equipment. This means IEs must be able to design systems of people, machines, materials, capital and so on, in a world that will be drastically different from the one they are trained and educated in. Yet the current

industrial engineering education and tools are rooted in an epoch that is in itself outdated for today's needs, and not to mention the future.

UoT continue to train IEs to primarily improve and integrate systems of people, materials, information, equipment, and energy. These core functions of IEs will be impossible to execute without the application of high-technology enablers (e.g., computer technology) in the future. It is impossible to enumerate the myriad of technology enablers that affects and will affect industrial engineers, but it is evident that these technology tools impact industrial engineering. Technology has drastically and dramatically altered the landscape of work for IEs and it has defined the work within which IEs will function, nonetheless what IEs of the future will call work.

IE problems are usually quite hard to solve due to a high complexity and the significant number of problem specific constraints (Davenport, 2003), therefore the use of computing technology become indispensable. IE education can no longer ignore the impact of technology on industrial engineering, and the reality that boundaries of function have seized to exist, and organizational culture has changed. And therefore, technology begets organizational culture change, which in turn begets technology. The practice of engineering must be changed, and this change can be accomplished through engineering education (Galloway, 2007).

Literature review

It is amazing how in all debates about the decline in education, the fundamental cause is ignored, that is, our students have changed radically (Prensky, 2001). Even when the gap between theory and practice in IE is accentuated by the gap in research and literature thereof, teaching and learning at the UoT does not resemble the postulated future environment in which IEs will function. Current industrial engineering education and tools are rooted in an epoch that is in itself outdated for today's needs, and not to mention the future (Wolfe, 2001) and today's students, are no longer the people our educational system was design to teach (Bennett et al., 2008).

There is little research published on the impact on computing technology on industrial engineering for almost a decade between 2008 and 2017. This is partly because, as alluded earlier, the theoretical landscape in the technology and pedagogy arena is dominated by theories dating from the 1960s and although the debate about the role of technology in education is not yet fully exhausted, but it has reached some maturity, since thousands of comparisons of scenarios of computing and noncompeting pedagogy have been made (Tamim et al., 2011). Bybee & Loucks (2000) stated categorically so that a deficiency of many industrial engineering schools is the fact that they have not yet recognized the potential application of IE to information systems. And for more than two decades, numerous journals, articles and studies prepared by professional societies e.g. the American Society for Engineering Education and others, have been discussing the critical need for change in engineering education (Galloway, 2007).

Yet despite the large library of literature on the subject of engineering education reform, the engineering curriculum of today still does not provide the foundation necessary to ensure engineer's success in meeting the requirements and demands of the global economy in the 21st century and beyond (Galloway, 2007). Unlike in the 20th century, today the success of an engineer will be measured against their ability to adapt to new conditions and technologies. And to remain competitive in this global and

knowledge-based economy engineers must be educated differently (Galloway, 2007). The devolution of engineering education in an effort to reduce the cost burden to students and to produce more engineers resulted in an emphasis on the technical aspects of engineering (Galloway, 2007). This process eliminated other critical aspects of engineering education and studies that are fundamental to the very essence of engineering, which is to improve the quality of life (Galloway, 2007).

The notion of real-time systems, as it is currently accepted, describes a computational process that has to respond to internal and external stimuli in determined periods of time (Ionescu et al., 2022). Such systems and processes have to be considered and responded to through engineering education. In various literatures, it is argued that the future of industrial engineering is based on computer technology and students will benefit more if industrial engineering education is based more on computer-based learning practice (Davenport and Short, 2003). Therefore, it can be argued that the use of computer technology is vital in industrial engineering education.

Theoretical framework

The Technology Adoption Model provides an appropriate theoretical framework to understand the factors that influence the adoption and use of new technologies. As such, it is critical to develop strategies to encourage the adoption of new technologies in industrial engineering. Therefore, the impact of computing technology on the future of industrial engineering is significant. The adoption of new technologies such as ICT, automation, robotics, AI, ML, big data, and analytics can lead to improved efficiency, productivity, and quality. It is thus, apparent that with the rapid development of computing technology, the role of industrial engineering is changing rapidly.

Application of theoretical frameworks, such as Technological Determinism, Innovation Diffusion Theory, Socio-Technical Systems Theory, Human-Computer Interaction (HCI) and System Thinking in research, makes it possible to comprehensively analyse the impact of computing technology on the future of industrial engineering. These frameworks provide a structured approach to understand the dynamics, challenges, and opportunities associated with the integration and adoption of computing technology in the field, ultimately guiding the development of strategies and policies for its successful implementation. The Technological Determinism Theory suggests that technology will drive social and cultural change, and the Innovation Diffusion Theory provides a framework for understanding the adoption of new technologies, therefore adoption of a theoretical framework is indispensable.

The research landscape in the technology and pedagogy arena is dominated by theories dating from the 1960s and although the debate about the role of technology in education is not yet fully exhausted, thousands of comparisons of scenarios of computing and noncompeting pedagogy have been made (Tamim et al., 2011). Technical computing has created a capability for IEs to solve complex problems that has been difficult to solve and high-performance workstations, supercomputers on the desktop and parallel computation in its many forms has created an environment where more difficult problems can be solved (Koelling et al., 1996). Therefore, a computer has become an indispensable tool of all business activities and an alienable component of industrial engineering (Davenport, 2018).

The role of computers has grown continuously over the past decades to a point of pervasive and self-propelling reliance on the machines. A good example is in the human aided computer design paradigm, despite the continuous enrichment of traditional CAD environments, the overall design procedure remains the same i.e., the human does the design, and the computer provides support tools (Tamim et al., 2011). But the complete structure of activities during the design of engineering artifacts can be very large, detailed and complex for any human to document and manage mentally (Stephanopoulos et al., 1990).

To create a capability to untangle and make explicit the design procedure for complex problems, thus emulating the designer's own methodology, the engineering design process is computerized (Fasano & Villani, 2012). There are therefore two areas of major advancement resulting from the use of computers in industrial engineering activities: (i) systemic modelling of the process of engineering design, and (ii) effective programming styles, which depart from conventional computer-aided design paradigms and allow the development of large highly complex computer programs (Stephanopoulos, 1990).

No one doubts the growing impact of computers and associated technologies on industrial engineering, and their potentially transformative properties (Davenport, 2011 & Tamim et al., 2011), except supporters of the debate by Clark (1986), which is focused on the impact on pedagogy. Albeit the strong evidence of the impact of technology on industrial engineering, there is still yet illusory evidence of acceptance with regards to academic institutions, especially UoTs in South Africa. The lack of acceptance to the impact of computing technology on IE is characterized by the lack of change in teaching and learning in the UoT.

Research method

The chosen research methodology for this study is a qualitative case study approach, which has been selected due to its ability to offer a comprehensive exploration and explanation of a phenomenon within its specific context, drawing from various data sources (Baxter & Jack, 2008). This approach facilitates a multi-faceted examination of the case, providing in-depth insights into the impact of technology on the field of Industrial Engineering (IE) and its curriculum in the context of online distance e-learning. To achieve the research objectives, we will employ various qualitative data collection methods, including a thorough review of current literature from academic journals, analysis of field notes, and examination of relevant documents.

These methods are well-suited for capturing the experiences and perspectives of participants, enabling the identification of significant themes and considerations concerning the integration of computing technology into industrial engineering practices. The research aligns with the exploratory and descriptive research design categories described by Yin (1994), facilitating a deeper understanding of participants' experiences and perceptions related to the impact of computing technology on industrial engineering. In accordance with Creswell et al., (2007) guidelines, the research will adhere to specific boundaries in terms of time, place, and context (Baxter & Jack, 2008).

The case study will be categorized as both explanatory and exploratory or descriptive, as it aims to address the following key propositions: (1) Assessing the impact of information technologies on the future of Industrial Engineers (IEs), and (2) Determining the necessary adaptations in engineering pedagogy. These propositions will serve as

crucial elements guiding the development of a conceptual framework for our research. The study is primarily desk-based, utilizing qualitative data collection methods. Yin (1994) and Patton (2002) highlight the importance of using multiple data sources in case study research as to enhance data credibility, a strategy employed in the research. Data triangulation approach will consist of the following sources: (i) document analysis, (ii) archival records, and (iii) field notes.

This approach is particularly valuable as it complements other qualitative methods, allowing cross-referencing and corroboration. Through the use of diverse data sources Rossman and Wilson (1985) have demonstrated the effectiveness of document reviews in identifying an organization's mission. While Sogunro (1997) highlighted its utility in providing insights into the history, goals, objectives, and content of the phenomenon under study. Document analysis is particularly suited for intensive studies that aim to produce rich descriptions of a single phenomenon, as emphasized by Yin (1994) (Baxter & Jack, 2008). The qualitative case study methodology employs a variety of data sources and triangulation techniques to comprehensively explore and explain the impact of technology on Industrial Engineering and its curriculum in the context of online distance e-learning. Through the rigorous analysis of documents, archival records, and field notes, the aim is to gain a deep understanding of this complex phenomenon.

Industrial engineering practice

IEs are confronted with challenges requiring complex and time-consuming analyses and the task of collecting and organizing data, and analysing patterns and relationships is a significant portion of the workload (Elfner, 1988). Mathematical models employed by IEs require sophisticated knowledge and analysis techniques and the calculating power required to implement these models in a working environment exceeds manual capabilities (Elfner, 1988). Computing technology has enabled IEs to perform various iterations of complex simulations and enable IEs to access complex data and engage in decision analyses resulting in decision support systems processes being implemented in engineering challenges. Development in computing provides IEs with the technology necessary for system design, which is core to the definition of IE.

Numerous problems have been modelled using advance computing, e.g. resource allocation and transport problems using linear programming; demand forecasting using linear regression models; and waiting lines and queuing theory models applying Monte-Carlo simulation. There are numerous modelling packages available for IE practice and some are general purpose analytical software such as Microsoft excel. These computing power tools are used by IEs in problem solving areas such (i) management decision making, which includes techniques such as forecasting and linear regression models; Linear programming applications and its transportation; probabilistic and deterministic inventory models; decision theory tools; including Markov chains and queuing analyses. (ii) Quantitative/statistical analyses which incorporate exponential smoothing time series forecasting models and extensive implementation of multiple linear regression for correlation forecasting analyses.

Project management tools included are CPM and PERT, investment analyses and facilities location models. (iii) Production and Operations management models can be simulated using Microsoft Excel and various solution models are deployed e.g., time series forecasting; simple EOQ and production scheduling algorithms. An IE has available to his /her disposal many adequate choices to consider amongst various

alternatives and the convenience of both commercial and educational computing software and collaboration tools, suggests that there is a need for an increased emphasis in the application of these technologies in educating industrial engineers. And therefore universities, in particular UoT in South Africa need to adopt a realistic approach to increasing the use of technology in educating industrial engineers.

Discussion

It is evident that the practice of IE needs to change further because of the demands for technologies and products that exceed the existing knowledge base and because of the changed professional environment in which IEs need to operate. This change must be encouraged and facilitated by changing engineering education curriculum. It is also apparent that there is a gap in existence between the theory on how IEs should be trained, based on the changing global trends and the impact of technology on IEs work and the working environment, when compared to the current IE curriculum in the UoTs. The gap is so wide it is as if IEs training in the UoTs are prepared for a totally different environment than the current high-technology setting and worse so, not to mention the future environment that will constitute the work of an IE.

This gap also manifest in the literature survey in that less research output is published on the impact of technology on IE, partly because thousands of comparisons of scenarios of computing and noncompeting pedagogy have been made since the 1960s (Tamim et al., 2011). To this effect, it is not surprising that studies and research for the past 20 years and more have been meta-analysed at intervals in an attempt to characterize the effects of new computer technologies as they emerge (Tamim et al., 2011). No wonder more than 60 meta-analyses have appeared in literature since 1980, each focused on a specific question that is meant to address the different aspects of the impact of technology, such as the type of technology (Tamim et al., 2011). It needless to indicate that although research studies comparing various forms technologies in use in both control and treatment groups are becoming popular, it does not mean that technology versus no technology comparisons will become obsolete (Sosa et al., 2010).

Technology tools are fun to discuss, but the bottom line is they impact on industrial engineers. It is evident how they may affect working lives of IEs, and much of the change is experienced already. But how will it affect the actual work IEs do? For example, how will work be measured in this new environment? There may be employees who have no need to be on site. Through e-mail, cellular communications, wireless computing, groupware, video conferencing and tele-presence, a virtual setting is possible. Benefits abound are reduced facility cost, reduced travel expenses, less pollution, more flexible time for employees, ability to handle special needs (e.g., working mothers, handicapped), and drawing skills from people around the world or from people whose skills otherwise may not be utilized.

For those organisations which have industrial engineering staffs, there are several problems confronting the I.E., involvement in information systems development, and these are, the in-house staffs are usually overburdened with routine activities which are, for the most part, comprised of traditional I.E., functions and can therefore not participate in other activities without increasing the size of the staff. Davenport (2018) noted that it seems that Industrial Engineers have paradoxically neglected the management and operation of computers. The I.E., staff and the computer centre are usually in different divisions and computer centre management is simply unaware of the potential application

of industrial engineering. Once the I.E., staff recognizes their role in information systems and overcomes their reluctance, the other problem areas can be overcome by selling themselves and what they can do to increase productivity in a computer-based environment.

It is evident that the working domain of the Industrial Engineer is certainly not limited to the traditional areas of application such as manufacturing. It is apparent that the skills and techniques of industrial engineering are applicable to improving the information systems development process and computer centre operations. Therefore, it is a challenge to educators and students of industrial engineering, as well as practicing industrial engineer's, to take advantage of this opportunity to play a significant role in the field of information systems.

Evidence to support a technology enhanced pedagogy for IE is found on the Engineering Council of South Africa (ECSA) 2014 review comments for the IE departments in UoTs. In the closing comments it was highlighted that the level of technology application is unsatisfactorily low and IE pedagogy in the universities does not reflect the demands of the working world in the 21st century. This comment supports postulates of Kozma (1991 & 1994) and those of Dede (1996) that computers possess affordances that can directly change the nature of teaching and learning (Tamim et al., 2011). ECSA declared that it is not prepared to give accreditation to IE programs that do not apply capabilities of information technology.

ECSA's declarations are concomitant to the declarations made by Davenport & Short (1990), that IEs aspiring to improve the work environment must apply the capabilities of information technology. And IE techniques and tools such as BPR and information technology are natural partners (Davenport & Short, 1990). The impact of technology on IE has been touted for more than a decade, yet industrial engineering have never fully exploited the relationship between technology and IE applications (Davenport & Short, 2003). ECSA in its recommendation to the IE department is clearly in congruence with Koelling et al. (1996) that indeed, it is certain that IE requires the expertise in computer technologies since technology impacts IE currently and in the future. Therefore, it is mission critical for IE profession to evolve and embrace the changes in the global work arena and in technology.

The evidence of this transformation in the work arena manifest through a phenomenon that clearly shows that the IE profession is in danger of losing its identity because other professions are encroaching on the IE traditional areas. It was Long et al. (2008) who postulated, that an IE with a basic knowledge of information systems and computers is qualified to succeed in the future, yet in almost four decades academic institutions (UoTs) have not heard the call to transform the IE curriculum to meet the demands of the future working environment.

The fact that academic institutions (i.e., UoTs in this case) have not yet recognize the transformative potential of information systems technologies in IE programs, is a deficiency for many UoTs today, as it was in the 60s and 70s, as is declared by Long et al. (2008) then and ECSA in 2004. An IE does not have to be a skilled in data processing, but for IEs to feel more confident and experience great success in the high-technology environment, IEs must be presented with a substantial body of knowledge in system

development processes, hardware, and system software technology (Davenport & Short, 2003).

An industrial engineering qualification will become obsolete, like any other product in the market, if there are no innovative interventions to keep the qualification current and relevant. Development in computing technology provides a great opportunity for innovation with regards to the curriculum and the content of various modules, in the qualification. Computing technology provides an opportunity to transform the delivery mode as per the institutions strategic plan. Figure1 (adapted from Rink and Swan 1979) depict a typical product life cycle and the design attributes commensurate, for continuous improvement of the product or qualification.

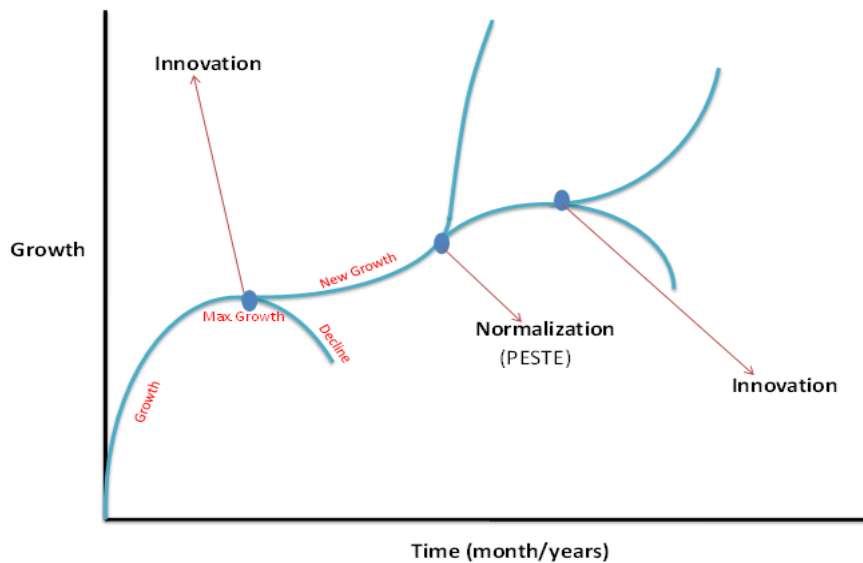


Figure1: Product life cycle for continuous improvement of a qualification innovation (By author)

The product life cycle in Figure1 depicts an initial growth stage and a maximum growth point is reached, and the product demand starts to decline. Marketing theory and Practice indicates that, if innovation is applied as soon as the product life begins to decline, then a new growth stage will emerge. Unless constant innovation is injected, as the product life begins to decline, the product will cease to grow and ultimately become obsolete. In terms of Industrial engineering the decline position means that the qualification will be outdated and irrelevant. And therefore, the Industrial engineering graduate will not be equipped to face the complex challenges in the industry.

Educating Industrial Engineers for the future work arena

As the computer has become an indispensable tool of all professions and business activities, it has become an inalienable component of industrial engineering education. From the age of keypunching computer cards (so called IBM cards) in the 60s to the age of portable laptop computers in the 90s, the mode of computer use has changed drastically. The majority of the industrial engineering courses contain a feature of using computers which may be either the mainframe or personal microcomputers. The degree of use may vary depending on the nature of the course.

It seems certain that the percentage of computer usage will increase every year. We have witnessed an increasing number of textbooks that include software packages.

Numerous institutions have tried to incorporate the use of computers in their courses by developing more courses and by selecting textbooks that have computer software packages. Many students have their own computers and their own software packages and know how to use the whole Microsoft package suit, thus, teaching and learning can be executed through cloud computing in the future.

Terry Anderson, in his book: Theory and Practice of on- line learning, indicates that the level of integration of technology and the extend of transformation varies from module to module, depending on elements of the education technology stack of the particular institution. This means various modules will achieve different integration and transformation levels as per the institutional functional strategy. Typically, a grid for integration and transformation of modules would indicate a position of a particular module in a range between on-line and off-line, and between contact base and remote/distance. The complexity of this transformation and integration process is intensified by the need for the convener of the migration project, to be in full comprehension of the curriculum strategic environment and the module content deliverables, as per the Anderson’s model of interaction in Table.1.

Table 1: Anderson’s Model of Interaction

<u>THEN</u>	<u>NOW</u>	<u>FUTURE</u>
F2F	INTRANETS	KNOWLEDGE
TEACHING	E-LEARNING	VLE
DISTANCE EDUCATION	EXTRANETS	NETWORKS

According to Anderson’s model, the migration of each module happens in a context where there is a full comprehension of the education technology stack (Figure2) and the institutional operations plan, understanding strategic environment dynamics and the envisaged deliverable of the curriculum. The grid in Figure2 depicts various positions for different modules as will be determined by the ease of integration and transformation of the module content.

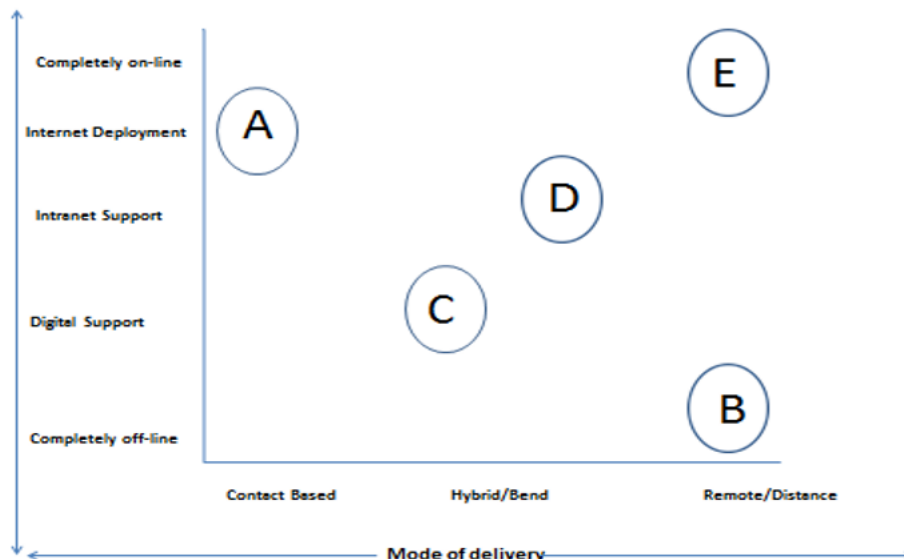


Figure2: Transformation progression Grid (Adapted from Anderson's Model of interaction)

Conclusion

In the near future, Industrial Engineers will be required to design and implement management, control, and visibility systems necessary to achieve optimization. Many information systems provide visibility; some provide control and enable management, but rarely does one provide optimization at all levels of the organization (synergy). Yet, optimization can be achieved by incorporating the industrial engineering tools of operations research and management information systems (MIS). To develop an applicable information systems environment, adequate consideration must be given to the analysis and design of the requirements of synergistic optimization.

The systems approach, with which the industrial engineer (IE] is so well acquainted, calls for detailed analysis, planned design, and total management and therefore, provides a means for a structured development of MIS. It therefore a logical conclusion to state that it is a duty of all academic staff in IE to ensure that all modules are on-line, that ODL platforms for teaching and learning are explored and implemented, and that we navigate towards teaching in a cloud computing environment. All this begins with the realization and embracing the impact of technology and specifically computers on the future of Industrial Engineering.

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A practical skills-based pedagogy in engineering education

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Abstract

The advent of COVID-19 brought about mandatory requirements for graduate engineering student to “hit” the ground running in industry. The Engineering Council of South Africa mandates Institutions to produce graduates with specific graduate attributes, especially in these times of rapid and unexpected economic and social change. These changes require universities to produce engineers that can transition into scarce skills positions and new occupations demanded by industry in various specific disciplines. The changing environment is influenced by emerging technologies that impact production, manufacturing, and service industries. Thus, engineering graduates must acquire skills that will enable a successful transition into jobs, which only occurs when engineering graduates leverage their acquired skills in their new occupations. Therefore, universities must strive to achieve the mission of engineering education, which is to produce engineers that can develop the technology of tomorrow to solve problems of tomorrow and to produce technologist that work with current technology to solve current problems. This research report adopts a qualitative research approach to explore and explain how engineers are trained to enable graduates to successfully transition into new occupation, with relevant graduate attributes required in industry. The research will deliberate on the teaching interventions engaged in Industrial Engineering undergraduate programs.

Keywords: Engineering, Skills, Technology, Covid19, Education

Introduction

There is evidence that blended classroom models can be effective only when the online elements are active rather than passive, according to a 2010 department of education report, undergraduate students in blended classroom settings had better assessment outcomes than purely online or face-to-face classes (Panda, 2014). The reason being that blended courses in which the students are spending their time online solving problems, moving through the material at their own pace, and spending half of class time in the online component of the class, have more positive learning impacts than both face-to-face only and purely online only (Allen, 1992).

Engineering education academics have always explored innovative teaching techniques, few instructional approaches developed entirely in engineering have achieved widespread acceptance. One that has is cooperative education, which was started at the University of Cincinnati in 1906 (Grayson, 1993). Cooperative programs in which students alternate semesters in school and periods of working in industry continue to be a popular option in engineering education. Another innovation that attracted widespread interest was adaptive digital game base learning (DGBL). Adaptive DGBL teaching and learning techniques have many similarities to problem-based learning, but it is more structured and relies more on computer technology (Arnab et al., 2012).

The utilization of gaming platforms is not cutting edge in education any longer, but from the perspective of an online distance electronic learning (ODEL) institution in South Africa, it is still a few years from becoming the main attraction and common practice in

the lecture rooms, as postulated by Bawden & Robinson (Bawden & Robinson, 2012). Online and large scale multiplayer educational games are being used in course work curriculum to leverage the best skills and techniques required from graduates by industry (Arnab et al., 2012). The best game theory in education leverage teamwork, leadership, discovery and tenacity, and these games are social networking games that compels students to create solutions for real-world challenges (Barseghian, 2012).

The largest distance education (DE) institution in South Africa acknowledges the fact that the generation of student enrolled with the university has changed from working adults to young, fresh out of high school students. This new group of students comprise of a large percentage of restless digital natives, who spend a big portion of their time online. In this changing teaching and learning (T&L) paradigm, the university has invested resources in figuring out how to use traditional engineering educational content for T&L in a game-based setting.

In this rapidly changing education environment, engineering technology education in a DE setting, has to be true to its mission. The mission of technology education is to produce technicians and operators to work with current technology, while that of engineering education is to produce engineers to develop the next generation of technology. While related to engineering in many respects, engineering technology is a more hands-on and thus DGBL is more relevant for teaching and learning in technology education. Therefore, a system with the ability to adapt intelligently to goal, tasks, interests and other features of individuals and groups of users, is an ideal engineering technology education medium.

Studies have shown that the more students work in cooperative learning groups the more they learn, the better they understand what they are learning, the easier it is for them to remember what they learn, and the better they feel about themselves, the class, and their classmates (Johnson et al., 1998c). Springer et al. (1999) meta-analysed the research for college-level science, engineering and technology and found significant effects on students' persistence and achievement in these fields and positive attitudes toward their education.

It is an undeniable fact, especially in DE, that it is no more possible to treat all students in the proliferating range of e-learning users with very different prior knowledge, backgrounds, learning styles, interests, and preferences, with the one-size-fits-all approach. An educational online system with the ability to adapt intelligently to the goals, tasks, interests, and other features of individuals and groups of users, is apparently mission critical for an online DE environment. Thus, in an attempt to bridge the gap between pedagogy and technology, the potential of new technologies should be used as a means to enhance Teaching and Learning.

An Online Distance Electronic Learning (ODEL) institution provides opportunities for working individuals who are engaged in other things but are keen to acquire a qualification or improve their skills levels through academic interventions. ODeL is a best-fit T&L paradigm for DE, because an e-learning framework seeks to establish an environment where students start fast with their learning activity by capitalizing on their down time and periods of time which they are not constructively engaged (e.g., riding a bus; waiting in a queue; during lunch and breaks) (Bawden & Robinson, 2012) and (Bommarito, 2014). In an ODeL institution, access is given to all potential students with

different competencies of the basic engineering modules such as mathematics and science. Some students have poor grades, while others have very good grades, thus an adaptive T&L strategy is critical.

Literature review

In the realm of engineering education, scholars have long been dedicated to exploring creative teaching methodologies. While numerous instructional approaches have been developed within the field, only a handful have achieved widespread recognition. One such approach is cooperative education, which originated at the University of Cincinnati in 1906, as documented by Grayson in 1993. Cooperative programs, where students alternate between academic semesters and industry work periods, have maintained their popularity within the field of engineering education. Another notable innovation that has garnered considerable interest is adaptive digital game-based learning (DGBL) (Beavis et al., 2015). This approach shares certain similarities with problem-based learning but distinguishes itself through its higher degree of structure and greater reliance on computer technology.

The integration of gaming platforms into education is no longer considered groundbreaking. However, when observed through the lens of an online distance electronic learning (ODEL) institution in South Africa, it is still a few years away from becoming the predominant and universally embraced practice within educational settings, as documented by Barseghian in 2012. Online, large-scale multiplayer educational games have now become a part of course curricula, aiming to cultivate the vital skills and techniques that industry demands from graduates, as emphasized by Arnab and their colleagues in 2012. These games, grounded in the fundamental principles of game theory in education, place a strong emphasis on fostering teamwork, leadership, discovery, and persistence. They manifest as social networking games that challenge students to formulate solutions for real-world challenges, as underscored by the insights of Bawden and Robinson in 2012.

Research indicates that when students engage in cooperative learning groups, they not only enhance their learning but also improve their comprehension, retention of information, and overall self-esteem. This finding was documented by Johnson and colleagues in 1998. Furthermore, a meta-analysis conducted by Springer and colleagues in 1999 focused on college-level science, engineering, and technology education, revealing significant positive impacts on students' persistence, academic performance, and their overall attitude towards their education. In the realm of distance education, it has become evident that employing a one-size-fits-all approach is no longer feasible, given the diverse backgrounds, prior knowledge, learning styles, interests, and preferences of the expanding e-learning user base.

In this context, the development of an online educational system capable of intelligent adaptation to individual and group characteristics, including goals and tasks, is crucial within the online distance electronic learning (ODEL) environment. To bridge the gap between pedagogy and technology, it is imperative to harness the potential of emerging technologies as a means to enrich the teaching and learning experience. This approach was advocated by Springer and colleagues in 1999, underlining the importance of leveraging technology to enhance educational outcomes

The transition to the knowledge era raised the contradiction from something dumb to be avoided, to human capital, to something to be cultivated within organizations (Palfrey & Gasser, 2008). Towards the higher education scenario, lecturers as core knowledge workers and are assigned to the task of developing new ideas and processes, by identifying, capturing, distributing, sharing, and encouraging knowledge development. Therefore, this implies adopting practices consistent with individual and organizational knowledge creation and learning processes (Takeuchi & Nonaka, 1995). However, the inconsistencies, polarities, dichotomies, and oppositions related to knowledge creation should not be considered improper, since it is formed by two complementary components: the tacit and the explicit knowledge (Takeuchi & Nonaka, 1995). Sveiby (1998) highlights that the practical knowledge is largely tacit, that makes the process of discussing knowledge even more complex.

In short, it can be said that tacit knowledge is internalized by the individual in a unique and personal way; therefore, it is not very easily articulated (Takeuchi & Nonaka, 1995). By the way, it results from individual configurations done through data provided by the environment the individual is inserted in, thus it is almost impossible for two or more people to develop the same knowledge when they receive the same information (Takeuchi & Nonaka, 1995). That is why such issue should be carefully treated when discussing the learning processes, hence the focus of this study. Takeuchi & Nonaka (1995) believe that the explicit or codified knowledge which refers to the knowledge transmitted through systematic and formal language, only exists in, lies on and is created by individuals. Explicit knowledge may be embedded, but its construction takes place when an individual interacts within a certain community.

Thus, the explicit knowledge can be expressed in words, numbers or even sounds that are often shared as data, manuals, audio-visual and scientific formulas. In this sense, developing knowledge means expanding artifacts created by a group of individuals within organizations. This is what Von Krogh et al. (2012) call enabling context. According to their view, academic perspective, is the enabling context and is composed of cooperative style of networking activities, of team building and of the support given to learning schemes such as mentoring and coaching (learning relationship that takes place when a more experienced professional takes the mentor/coach position and shares knowledge with the fresh player).

These features promote an environment where ideas are naturally created, since knowledge is essentially related to human actions and, its development process depends on the participants and the action they take (Teicher, 2018). The complexity of the knowledge transmission process that contemplates the learning process, and its requirements and facilitators from the enabling contexts for job readiness, requires the use of Intellectual Capital (IC) taxonomy in three dimensions (Stake, 1995). Since it is one of the most accepted bases for studying the intangible assets and their impact on the value creation.

According to Faste (1994), this thinking paradigm encompasses possibilities inherent to the proficient use of both hands in performing an activity and, by extension, the use of the whole body and even the mind leading to wider possibilities linked to synaesthesia as a way of learning. Resorting not only to the symbolic level but also, to the sensory level and also those inherent to recognizing the importance of the brain hemispheres and modes as basis for decision making (Bartunek, 2014). The judgement and decision-making

process represents the essence and the excellence of the role played by the managers in the Neuro-economics (Setzer, 2001).

Didactic pedagogy and conceptual distance between lecturers focused on the practice and those focused on the theory creates pedagogical noise regarding the academic unit of the undergraduate engineering course. As for an equivalent point of view, Bartunek (2014) discusses the need for pracademics in teaching and in the final delivered product from a university of technology. This transformational paradigm would be achieved by developing an ambidextrous mental model, able to mediate and bring together logics and boundaries that delimitate the academic and the corporate worlds, which are, at first exclusionary (Schwab, 2016).

Scientific rationality and instrumental rationality would need to be reviewed and realigned in order to get better results in the professional education of engineering technologists (from simple training courses engineering science and mathematics to teaching 3IR skills that will enable graduate to transition into scarce skills positions and new occupations demanded by industry) and allow generating and improving theories that fit into practitioners' daily needs. The inability to deal with the increasing gaps between knowledge produced in universities of technology and that actually needed, have the industry blocking the research agenda with discussions on relevance and rigor, when, in fact, it should focus on debating relevance and applicability (Nonaka & Konno, 1998).

This T&L perspective would allow escaping the teaching and learning (T&L) traditional logic of industry positioning and operational efficiency planning by providing the institution with good conditions to innovate through exploration and exploitation, alternately. Education institutions would find in the thinking paradigm settled between managers and educators, an effective tool to survive in times of great transformations in students' profile. This T&L paradigm will increase communication with stakeholders and with the manifesting prospects through guidance based on engineering education authorities such engineering council of south Africa (ECSA). More so this, forecasting the opportunities will come from the internet of things (IOT) and the fourth industrial revolution (4IR).

Research method

Qualitative case study methodology affords researchers opportunities to explore and explain a phenomenon within its context using a variety of data sources (Baxter & Jack, 2008). This approach ensures that the phenomenon under study is explored through a variety of lenses that allows an in-depth understanding and allows multi facets of the case under study to be revealed and understood Baxter & Jack (2008). The case study approach aligns to the goals of this research in that the focus of the study is to explore and explain with the aid of a comprehensive example that illustrates whether and how the application of technology tenants of the fourth Industrial revolution, impact, aligns and integrate how engineers are trained to enable graduates to successfully transition into new occupation, with relevant graduate attributes required in industry. This type of research approach covers the contextual conditions in which the phenomenon under study occurs (Takanishi, 2019).

The unit of analyses (the case) in this study is the impact of technology integration, through vertical and horizontal activity integration, on how engineers are trained to enable graduates to successfully transition into new occupation, with relevant graduate attributes

required in industry. The attributes of this research satisfy the definition of a case as stipulated by Patton (2002), and they are in line with Patton (2002) and Yin (1994) stipulations concerning setting boundaries for cases in a case study research approach (Baxter & Jack, 2008). The research also appeals to boundaries stipulated by Creswell, those of time and place (Baxter & Jack, 2008). In line with the boundaries of the definition and context, and the research question (how engineers are trained to enable graduates to successfully transition into new occupation, with relevant graduate attributes required in industry?), the type of case study research adopted, aligns with explanatory and exploratory or descriptive case study as categorized by Yin (1994).

Patton (2002) and Yin (1994) stipulate that a hallmark for case study research is the use of multiple data sources. A strategy that enhances data credibility (Baxter & Jack, 2008). This case study will apply a triangulation of the following data sources i) document analysis and archival records and ii) field notes; and iii) T&L system design applied. It is rational to apply document analysis in this research since it is often used in combination with other qualitative research methods as a means of triangulation. The combination of data collection methods in the study of the one and the same phenomenon enables researchers to draw upon multiple sources of evidence and, to seek convergence and corroboration with different data sources (Baxter & Jack, 2008). This approach ensures improved data and decision credibility and eliminates researcher bias in recommendations and conclusion.

Based on the theoretical framework established by various authors indicated above, the research adopted a qualitative case study approach in which a desktop research approach is engaged. The research applies data collection and analysis method of i) document analysis and archival records, to establish literature reviews and current status in the teaching and learning in technology education. Then, ii) field notes of previous researchers are examined to capture the reality and the essence of teaching and learning in the institutions technology and technology teaching and learning in action.

This method is applied in order to gain understanding of the cold phase with regards to teaching and learning activities, so as to enable superior activity integration in the technology-based teaching and learning design. The last data collection method is iii) the technology teaching and learning data analysis method. This method is applied to collect data required in the design of the technology teaching and learning system and to identify all the required process steps in the application of ambidexterity in the teaching and learning processes. The data collection tools will enable the research to be approached in three ways and therefore the resultant is an improvement in data integrity.

Discussion

The teaching and learning program begins with an engineering curriculum established as a combination of applied engineering theory and a hands-on instruction. Courses on mechanical drawing and design of engineering equipment are core in the instruction of engineering technologists. Engineering design is included because it is a linear and morphological process that requires a hands-on approach in instruction. The program is implemented as an engineering technology instruction that emphasize more on synthesis as opposed to analysis, that is, course content includes design thinking related courses rather than scientific analysis and mathematical modelling.

In the execution of the teaching and learning program, two components of the program followed are, learning and applying a programming language, in this case students learn how to use Python. The second component is engineering design, in which students learn how to build equipment using Lego-robots material. In engineering design, student use drafting and drawing methods in the conceptualization of the products and then manufacture the products using Lego components. Students are encouraged to build equipment that require mobilization, e.g., mining equipment or manufacturing conveyor belts. This type of equipment requires motors, sensors, actuators, etc.

Robots are very mechanical, most of these are still unintelligent mechanical arms. Learning robot technology started to develop in the 1970s, WABOT-1, the first anthropomorphic robot, appeared in Japan in 1973, sparking research on bipedal walking functions in robots into the 1980s (Takanishi, 2019). Robots had to be tediously hand-programmed for every task until about the late 1970s; to overcome this, robotics needed machine-learning technology (Moll, 2021). Increasing demand in the 1980s for robots capable of identifying parts from random selections, or maintaining positional accuracy when objects shift about on assembly lines (Yerkey, 1984), brought machine learning into robotics.

Student are exposed to Machine Learning, which in this program is limited to the capacity of computers to learn from experience by improving their information-processing ability over time by running algorithms to access and process data. Students are encouraged to research further and engage in concepts such as Deep Learning, which is an evolution of machine learning, that creates an artificial neural network that can learn and make decisions on its own. The teaching and learning philosophy adopted is gradual release of responsibility (GRR), in which student are encouraged and resourced to research further about any of the topics in the 3IR and 4IR space.

The program acquired a 3D printing machine and student are introduced to additive manufacturing, Additive manufacturing 3D printing machine applies a technology known as fused deposition modelling (FDM), which is commonly known as desktop 3D printing because it is the most commonly used form of the technology today. There are other technologies applicable in additive manufacturing such as SLA, SLS, but FDM make up the bulk (90%) of our 3D printing teaching and learning program and, clearly this technology constitute an enduring, innovative technology of the 3IR.

Student are introduced to the internet of things (IoT), which in this program is taught as a system of networked mechanical and digital devices with the ability to transfer data amongst themselves without human intervention. The core technology of the IoT is the Internet, and converters used are from analogue to digital (ADC) and from digital to analogue (DAC), which students use to link mechanical devices via sensors and actuators into the IoT. Student study and replicate well known projects such as the Carnegie Mellon University installation of micro-switches in a vending machine to check cooldrink availability from their desks (Von Krogh et al., 2012).

IoT application using converters, sensors, and actuators, is extended to experimenting with regulating the temperature of a fridge remotely, switching light on and off by clapping hands and topics around smart houses, such as energy saving IoT projects. Some students in the GRR part of the program ventured into cyber security and household security related topics such as motion analysis and energy consumption. Solar energy

supporting designs that came out this program include designing a motor that control solar panels to follow the sun movement, so as to optimize solar energy generation.

This program pivots around mechanical robots building and mobilization using programming languages such as Python. The program allows students to venture further in deep learning and machine learning, and support is provided to students who want to expand their knowledge with regards to 3IR technologies and the commensurate skills for the 3IR economy. The 3IR technology skills program is at its infant stages and runs for one (1) year, beyond the academic year student become part of the robotics and e-sport club in the industrial engineering department, in order to continue engaging in the 3IR skills program.

It is apparent that further development of the 3IR skills training program will lead the teaching and learning to focus around ten (10) topics only for an academic year. Student who want to engage further will be well resourced and supported to research further and to create innovative products. The major topics of 3IR, that the program will focus on are the following: Robotics, Machine learning, IoT, Automation, 3D Printing, Big Data, Digitalization/Digitization, AI, and Augmented/Virtual reality. The reason that our institution operates in Online Distance electronic Learning (ODEL), makes these technologies favourable.

Research results

Students succeed in completing the first challenge, which is improving current and existing technology. Projects such automating the university boom gates and installing of micro-switches in a vending machine to check cooldrink availability remotely, are an indication of students acquired competence in technology improvement. This is an achievement of the mission of engineering technology education (to produce technologist that work with current technology to solve current problems). As this cohort is an Industrial Engineering group, they challenged to apply continuous process improvement (CPI) technics to improve the limitation of the systems they have designed and manufactured. While Kaizen is in full swing, it is noticed that the skills in applied engineering theory (design thinking) and a hands-on instruction (Ambidexterity), kicks-in, and students solve numerous technology problems by applying both.

A typical solution manifesting from this stage, is the design, manufacturing, and application of a solar panel motor. The solar panel motor improves the efficiency of the solar panel by controlling solar panels to follow the sun movement, so as to optimize solar energy generation. Production of new technology is proof that student have moved through a tipping point (fig.1), i.e., from improving existing technology to producing technology (from evolution to transformation). At this stage, it is noticed that students are applying skills of design thinking and Ambidexterity with very high competency. This leads to the second tipping point, where student engage the world of digital technology. In this stage students produce apps to identify potholes in the university neighbourhood and manufacture pothole filling material using additive manufacturing skills. A myriad of projects are done in this stage that support the notion that students are working with current technology to solve current problems. Some of the project done at this level include smart housing and cyber security projects.

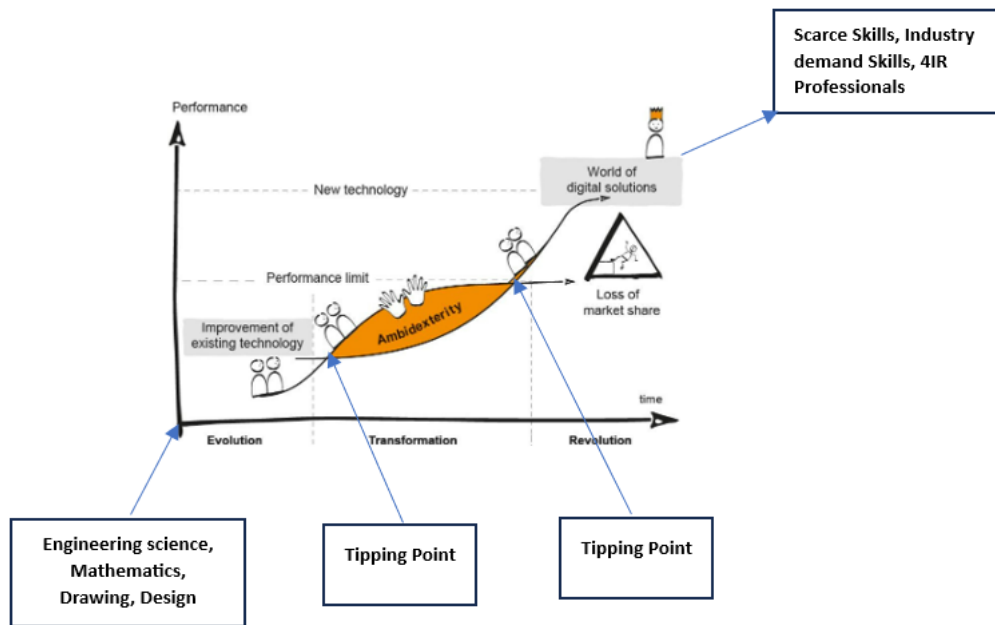


Figure 1: Technology Education mission (Teaching and Learning Model adapted from Duwe, 2018)

Three major aspects of T&L are achieved in this program, i.e. Capture student's interest, Motivate students in progressing to higher and more difficult levels of learning, Learn from and interact with other students. These are typical results of a DGBL environment and GRR pedagogy. Students achieve self-motivation, they collaborate to solve challenges and like in game-based learning they go through solving problems to a higher level. The T&L program proves that an education online system with the ability to adapt intelligently to the goals, tasks, interests, and other features of individuals and groups of users, is apparently mission critical for an online DE environment. Thus, in an attempt to bridge the gap between pedagogy and technology, the potential of new technologies are used as a means to enhance Teaching and Learning in a distance learning setting.

Conclusion and recommendations

The realization that all the technologies in the program represent a gradual evolution of the defining technological transformation of 3IR tenants (Moll, 2021), is the foundation of the drive and commitment to teach 3IR technology skills, and the believe in engineering education mission. The program success is proof that once the students are confident and knowledgeable about the 3IR economy and the engineering dynamics involved, they will be activated to transition into establishing themselves as proficient 4IR professionals. Thus, 4IR is evidently a staggering confluence of emerging technology breakthroughs, as proposed by Schwab (2016) and it blurs the lines between the physical, digital, and biological spheres through artificial intelligence application, as postulated by Marwala (2020).

The mission of engineering technology education is to produce technologist that can work with current technology, and therefore, engineering curricula must be a combination of applied engineering theory and a hands-on instruction. This pedagogy strategy have achieved the mission of engineering technology education. T&L of courses on mechanical drawing and design of engineering equipment must be core in the instruction

of engineering technologists. These courses must emphasize more on synthesis as opposed to analysis, that is, course content must include design thinking related courses rather than scientific analysis and mathematical modelling. It is undeniable evidence that university is able to meet the requirement of ECSA and produce graduates who can successfully transition into new occupation, with relevant graduate attributes required in industry.

It is thus, fitting that engineering curricula must include 3IR technology skills teaching and learning programs, so as to afford engineering students an opportunity to develop 4IR skills and ability to participate in the development of the 4IR economy. Currently, it must be noted that teaching 4IR technology skills paradigm is rather complex, since 4IR technologies manifest because of the convergence, confluence, and evolution of the clearly defined technological transformation of 3IR technologies, as indicated by Moll (2021). Therefore, McGinnis (2018) propositions, that 4IR is a fusion of advances in 3IR technologies, such as robotics, AI, etc, is plausible and core to the strategic believes in this 3IR technology skills teaching program. The success of the program is proof that a Skills-Driven pedagogy for Job transition pathways applicable in Engineering Education can successfully transition engineering graduates into new and scarce skills occupation, with relevant graduate attributes required in industry.

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The use of social media and the academic performance of undergraduate university students in Mauritius

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Abstract

The ever-increasing proliferation of mobile technologies during the pandemic era of COVID-19 has increased the use of social media, more especially in universities where the technology is transforming the way students communicate, collaborate, interact and learn (Zarzycka *et al.*, 2021). However, multiple aspects must be considered as it might affect their academic performance positively or adversely. This research aims to explore the impact of the use of social media on academic performance among undergraduate students in Mauritius. It also seeks to examine the factors that might influence the nature of this relationship, and its tentative impact on the academic performance of Mauritian University undergraduate students. This study employs a mixed method where the qualitative part of the study was met through the conduct of a focus group from the input of undergraduate students studying in both private and public universities in Mauritius. Survey method was adapted to collect the relevant quantitative data for the study. The relationships between the various variables in the study was investigated using correlation, and regression analysis. The results show that students used social networking sites for educational and non-educational purposes. The findings revealed that use of social media have significant positive relationship with the students' academic performance.

Keywords: Social media, Academic performance, undergraduate learners', Mauritius

Introduction

In today's world, social media has become an integral part of our social life. Social media is seen as a communication and interacting platform that could be utilized to enhance our connectivity, research, and learning. Social networking sites and applications are widely used by students. They spend a lot of their time on these sites as a part of their daily lives (Kolhar *et al.*, 2021). In recent years, its usage has increased dramatically among the youth and young adults, particularly students being the primary users of social media, with excessive use and a high number of students spending time online, raising the question of whether excessive use of social media can affect academic performance.

The advancements stated by Zhao *et al.* (2018) in social media technology have impacted every aspect of society and individuals in recent years. Individuals accessing e-mail, text, multimedia, interactive videos, e-book, etc. via social media has become a norm in daily life. Indeed Wario (2022) mentioned that the proliferation of social media in the present age has revolutionized our way of communicating and learning to the extent that it has become our preferred medium of everyday communication and learning. Social media is also seen as a learning tool that could be utilized to enhance student engagement and improve learning and performance. It offers multiple opportunities to both students and institutions to improve teaching and learning methods. Through these networks, students can communicate, get in touch, access information, research, and collaborate. Additionally, institutions can communicate and share important information such as campus news as well as learning resources to students who are connected to the relevant

networks and sources. Because of its pivotal role in aiding our communication, the use of social network sites has increased globally and continues to increase.

Regarding the social media statistics for Mauritius in 2022, *Global Digital Insights* (Kemp, 2022) mentioned that there were one million social media users in Mauritius in January 2022. The number of social media users in Mauritius at the start of 2022 was equivalent to 78.6% of the total population, but it is important to note that social media users may not represent unique individuals. Analysis reveals that social media users in Mauritius increased by 71 thousand (+7.7%) between 2021 and 2022. Within the 21st century, the use of the Web (including social media) has universally become a fundamental part of students' day-to-day lives (Sorensen, Ponas, Hayikhani and Hayar, 2014). The intensified use of social media is a worldwide issue, and with the constant upgrades in ICT and the growing opportunities for pervasive internet network, the social media platforms such as Whatsapp, MySpace, Twitter, LinkedIn, Facebook, Youtube, Instagram, Blogs, and others will persist to change the manner in which learners get to, create, share and utilize information. With the likelihood of having online network access any place and at any time, it is important to note that use of social media will continue to be a usual facet of students' lives. Social media utilization is as of now unavoidable, nevertheless numerous consequences of its particular use by students are not sufficiently exposed and may not be till purposeful researches are made to disclose them.

Studies revealed that among the various age groups of students, university students are among the most using social networking (Azizi *et al.*, 2019). Therefore, this research aims to explore the impact of the use of social media on academic performance among undergraduate students in Mauritius. It also seeks to examine the factors that might influence the nature of this relationship, and its tentative impact on the academic performance of Mauritian University undergraduate students.

Literature review

The increased use of social media mentioned by Amin *et al.* (2019) that among tertiary students is one of the highly growing phenomena in academia. Various studies by (Kushin and Yamamoto, 2010; Majid and Yuan, 2006; Hashim *et al.*, 2015) showed students' high involvement in using social network websites to interact with their lecturers and discuss learning materials. According to Kushin and Yamamoto (2010) social media helps students to communicate, and create a network with each other through comments, posts, and information sharing. From the observation, it is almost not surprising that a large number of students as a society of learners rely on different social media tools and websites to increase their academic achievement and this has been done through knowledge-sharing activities, and learning management in electronic learning. It is disclosed that the expanding use of different social media tools all around the world (Hashim *et al.*, 2015).

Findings of Vézina (2014) have been acknowledging YouTube, Twitter and Facebook in teaching and learning processes. In this case, the researchers have raised concerns that students must develop the ability to interact, work, communicate, find, and share knowledge consistently to present an ever-changing E-learning environment. Online peer learning via social media as a "technique" is widely used to promote attainment in students." Students are motivated to learn, comprehend, and review material when they are put into a teaching task.

An investigation was conducted by Al-Rahmi *et al.* (2015) on the improvement of student's academic performance by using social media through collaborative learning in Malaysian higher education where the researchers sampled and studied both undergraduate and postgraduate students at University Teknologi Malaysia (UTM) to understand the impact of social media on academic performance and the possibility of using them as an effective pedagogical tool to improve academic performance. The findings show that social media affects positively and significantly collaborative learning through interaction with peers, interaction with supervisors, engagement, perceived ease of use, and perceived usefulness.

The following study has carried out by Melani and Andrew (2017) to examine the influence of Social Media on the Academic Performance of students following Bachelor of Business Administration programme at Eastern University of Sri Lanka. Findings show that the use of social media has a significant influence on student's academic performances and further recommended students should be encouraged to use social media for educational purposes. Similarly, Talaue *et al.* (2018) attempted to analyse the impact of social media on academic performance and found that usage of social media negatively impacts on academic performance of students due to the time spent on social media stressed them. On the other hand, Hasnain, *et al.* (2015) ascertained an inverse relationship of the use of social media with the academic performance of the students in Pakistan. Emeka and Nyeche (2016) also revealed that the use of the internet for educational purposes enhances undergraduate students' skills, knowledge and capability to improve their professional lives in future with the help of their study done among the students studying at the University of Abuja, Nigeria.

An increase in time spent on social media would result in a deterioration in the academic performance of students because they have less time to study. Previous studies suggested that social media addiction has a negative effect on students' academic performance, interpersonal connections, and general well-being (Alaika *et al.*, 2020; Whelan *et al.*, 2020). While Zahid, *et al.* (2019) concluded that the use of social media by the students has helped them in exchanging and generating new ideas.

Although the studies by Suganya, *et al.* (2020) revealed that time duration of social media utilization and its addictiveness has a significant negative impact on the academic performance of students, exposure to social media and the nature of usage doesn't have any significant impact on academic performance of students. Further, it was found that there is no significant difference in using hours of social media for educational and non-educational purposes among the students studying in different years. Many studies supported that there is a negative relationship between students' addiction to social networking and their academic performance (Ndubuaku *et al.*, 2020; Azizi *et al.*, 2019; Stankovska *et al.*, 2016).

The main benefits that social media offer in educational settings stem from their value as a tool for information exchange and sharing (Asterhan and Bouton, 2017) and as a means of socialization and communication (Balakrishnan and Lay, 2016; Macià and García, 2016). Social media platforms come with many educational materials, which help students broaden their scope of knowledge as well as develop various good skills and talents (Dahlstrom, 2012). The finding of the studies conducted by Kolhar *et al.* (2021) showed that 97% of the students used social media applications. Since students tend to spend more time on social media other than for educational purposes, this tends to cause

distraction from the learning environment, affecting their academic progress (Bekalu *et al.*, 2019; Hettiarachchi, 2014). Further, spending a lot of time on social networking sites can lead to a sedentary lifestyle and a decrease in daily physical activity levels, which in turn can render them vulnerable to non-communicable diseases such as obesity, diabetes, and hypertension (Melkevik *et al.*, 2015; Zou *et al.*, 2019).

Methodology

The research adopted a mixed method to collect both quantitative and qualitative data. According to Creswell (2012), “a mixed methods research design is a procedure for collecting, analyzing, and mixing both quantitative and qualitative methods in a single study or a series of studies to understand a research problem”. The information was collected through a desk review of the literature, focus group discussions and questionnaires. It used the sequential explanatory design, where data was collected over in two consecutive phases. First, the quantitative data was collected and analysed and subsequently the qualitative data were collected and related to the outcomes from the first, quantitative, phase.

The research focused on undergraduate students studying in Mauritius. The sample of the study was derived from the population of 14,194 students who were studying in the following institutions as University of Mauritius (UOM), University of Technology of Mauritius (UTM), Open University of Mauritius (OU), University des Mascareigne (UDM), Charles Telfair Institutes (CTI) and University Middlesex. The sample size of this study was 389 learners using Slovin formula and a simple random sampling technique was adopted for the study to select the students. This technique was used to ensure that each member of the target population has equal and independent chance of being chosen as respondent for the study.

The research instrument used for the study was questionnaire, which was designed in three sections - Part I captured the demographic characteristics of the students. Part II focused on social media usage and the preferable social media sites, consisting of 22 Likert-scale questions that elicited information about students’ use of social media and Part III examined social media’s impact on the academic performance of the students: Strongly Agree (SA), Agree (A), Neutral (N), Disagree (D) and Strongly Disagree (SD). The qualitative part of the study was met through the conduct of a focus group from the input of students who reported that social media had a positive influence on their performance, a negative influence, and those who did mention that social media had no impact on their performance. A stratified random sampling technique was applied to get a representative sample covering different characteristics such as gender, academic status, and major.

SPSS 23 was used for the analysis where both descriptive and inferential statistics was used. The inferential statistics included frequency counts, percentages and mean which attempted to assess the significance of the hypotheses and relationships between the various variables in the study investigated using independent t-test and ANOVA. Since the research investigated the relationship between academic performance and the use of social media, the uses of social media were measured number of hours, number of study hours and CPA (independent variables). The relationship between independent variables and dependent variables were tested using regression analysis. The following regression models were constructed:

$$APS = \alpha_1 + \beta_1 TD \quad (1)$$

Where

APS: Academic Performance of the students

TD: Number of hours of use of social media

$$APS = \alpha_2 + \beta_2 SH \quad (2)$$

Where

APS: Academic Performance of the students

SH: Number of hours of use of social media for study

For the qualitative component of this study, based on the focus group from the input of students who reported that social media has a positive influence on their performance, negative influence, and those who did mention that social media has no impact on their performance.

Result and discussion

Figure 1 shows the results of the gender distribution of respondents 70.67% were female and 29.33% were male. This indicates that the majority of respondents are female. On the other hand, Figure 2 shows that field of study of participants 52.67 % were from management, 34.00% were from science, 6.67% were from Art and 6.67 % were from Law.

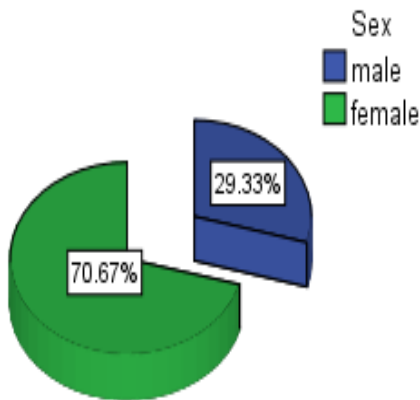


Figure 1: Gender

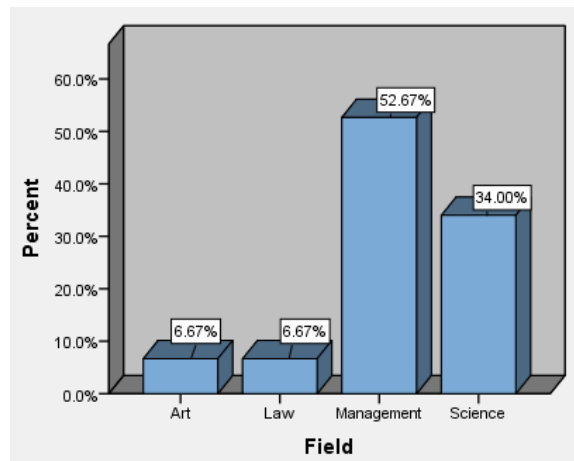


Figure 2: Field of Study.

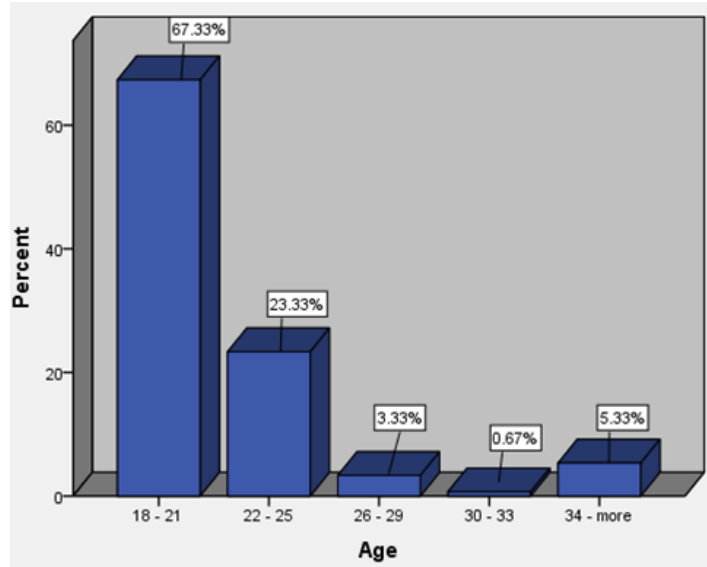


Figure 3: Age group

From the Figure 3 above, it can be seen that the majority of the participant fall in the age group of 18-21 years old (67.33%) and 22-25 years (23.33%). This reflects the study conducted in Malaysia where 76.80% of respondents were between the age range of 18-35 years old (Amin *et al.*, 2019). Likewise, Kolhar *et al.* (2021) in their research had the majority of participants aged 20-24 (65.00%) years old. Table 1 shows that categories age as follows between 18-21, 22-25 and 26-29 go online very often with a percentage of 68.4%, 21.4% and 3.4% respectively, with a negative correlation of -0.017, it is observed that there is an inverse relation as the age rises the number of hours spent online decrease.

Table 1: How often go online according to age group

	How often going online		
	Very often	Often	Not very often
18 – 21	68.4%	65.6%	0.0%
22 – 25	21.4%	28.1%	0.0%
26 – 29	3.4%	3.1%	0.0%
30 – 33	0.9%	0.0%	0.0%
34 - more	6.0%	3.1%	0.0%

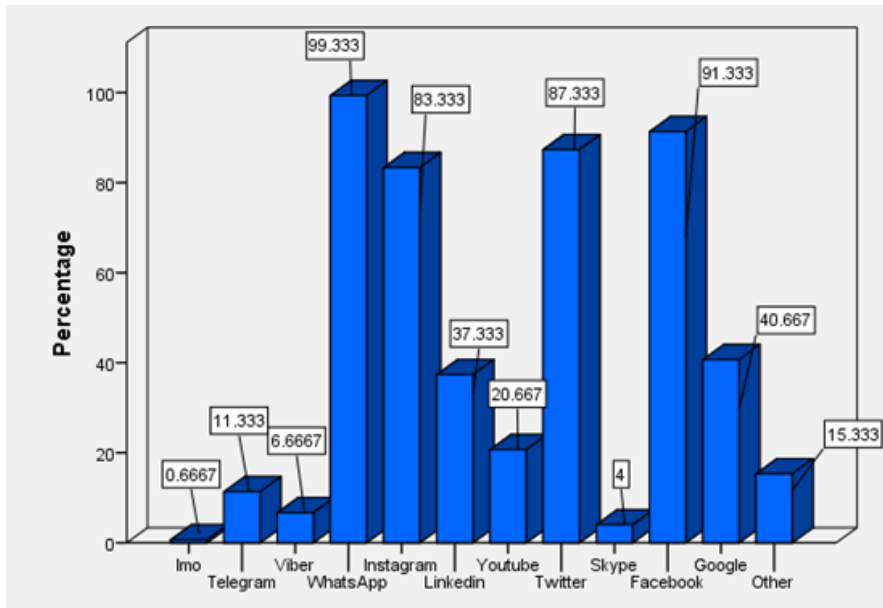


Figure 4: The most dominant social media tools used by respondents

Figure 4 shows that WhatsApp (99.33%), Facebook (91.33%), Twitter (87.33%) and Instagram (83.33%) are the most popular social media sites amongst young undergraduate universities in Mauritius. These findings followed the same argument of the report research by Wario (2022) who added that WhatsApp (99%), Facebook (93%), Instagram (84%) and YouTube (65%) are the most popular social media sites with young audiences leading the use in South Africa. Similarly, Suganya *et al.* (2020) results have shown that Facebook (51%), Viber (36%) and WhatsApp (8%) are the most popular social media sites used at the University of Jaffna, Sri Lanka. They reported that more than half a percentage of sample students are using Facebook (51%) most frequently than other media as it is provided higher facilities to keep contact with friends and relatives. The findings of Amin *et al.* (2019) revealed that tertiary students have access to social media and Facebook, which is a tool that is mostly used by students of the university. However, it is evident in the findings that Facebook is the most frequently used social media application as agreed by the majority of the respondents.

The results show that 11.4% of males and 18.9% of females are spending 2-3 hours on social media per day where ‘as 11.4% of males and 8.5% of females are spending 8 or more hours on social media per day. It was observed that males are spending more time on social media compared to females per day. This was supported by the study conducted by Wario (2022) where approximately a third (32%) of respondents indicated spent between 6 to 8 hours on social media daily, 31 % spent 3 to 5 hours, 28% spent more than 8 hours on social media, and 9% spent 1 to 2 hours. Because of the long hours spent on social media platforms, the majority of respondents (64%) indicated social media harms their academic performance in contrast to 4% of respondents who disagreed. Figure 5 shows clearly for 8 or more hours that males spend more time using social media per day compared to females. From the figure below, it is clear that males are spending a longer time on social media than compared to females per day. This finding reflected the study conducted by many researchers (Ndubuaku *et al.*, 2020; Azizi *et al.*, 2019; Stankovska *et al.*, 2016) who found a negative relationship between students’ addiction to social networking and their academic performance. Male students were addicted at a higher level compared to female students.

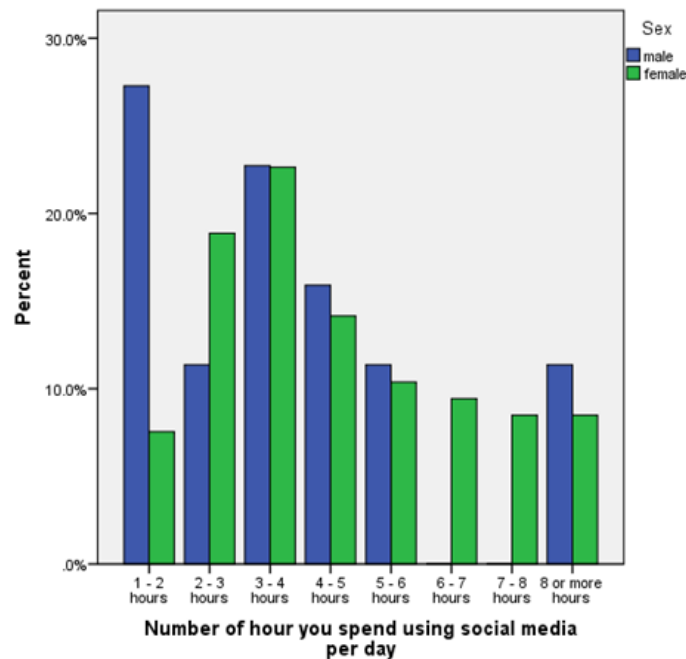


Figure 5: Number of hours spend using social media per day according to gender

The findings show that females (17.9%) and males (18.2%) spend 2-3 hours studying per day. It is also noted that females (8.5%) and males (2.3%) spend 6-7 hours studying per day. Zhao *et al.* (2018) also stated that females used smartphones for educational purposes compared to males, supports these findings. In addition, it was revealed that females use more of social media for study purposes than males. The results of Zhao, *et al.* (2018) also indicated that female students used smartphones more frequently for learning compared to male students, in contrast to the study by Jambulingam & Sorooshian, (2013) where the authors deduced that there is no significant differences among Malaysian female and male tertiary students.

The results also indicated that the age group 18-21 years old 5.9% and 22-25 years old 8.6% spend 8 or more hours studying per day. A correlation of -0.119 described an inverse relationship between the number of hours spent studying per day and age group. Reynol (2012) identified that time spent checking Facebook adversely affects the academic performance of students in their studies. Literature revealed that students who spent more time on social networking show adverse academic performance (Paul *et al.*, 2012; Kirschner and Karpinski, 2010). Furthermore, it was reported that males (59.1%) and females (64.2%) agreed that the use of social media facilitates academic performance. It was noted that males (22.7%) and females (27.4%) strongly agreed that the use of social media facilitates academic performance. A positive correlation of 0.135 showed that females agreed more frequently than males that the use of social media is a tool to facilitate and improve students' academic performance. It was clear that both genders agreed that the use of social media facilitates academic performance. However, it appeared that females agreed and strongly agreed more than males that the use of social media is a tool to facilitate and improve students' academic performance (Wario, 2022). In addition, 39.4% of excellent performance and 22.4% of average performance had strongly agreed that the use of social media facilitates academic performance. Mensah and Nizam (2016) reported that there is a positive and significant association between the nature of the usage of social media and student's academic performance in the studies.

The linear regression equation is as follows:

$$y = 1.83 - 0.01x \quad (1)$$

Where

y : Academic Performance

x : Number of hours you spend using media per day

There is a slight decrease in academic performance over a longer period-spent using social media per day. This reflects the study by Wario (2022) who mentioned that long hours spent on social media platforms, the majority of respondents (64%) indicated social media had a negative impact on their academic performance in contrast to 4% of respondents who disagreed. This finding corroborates the arguments made by other researchers who suggest that students who spend much time on social media platforms for chatting and socialising are likely to perform poorly in their academics (Owusu-Acheaw and Larson, 2015; Asemah *et al.*, 2013).

The linear regression equation between number of hours spent studying using social media per day and academic performance is as follows:

$$y = 1.9 - 0.03x \quad (2)$$

Where

y : Academic Performance

x : Number of hours you spend studying using media per day

A decrease in academic performance over a longer period spent studying per day on social media can be revealed. Previous studies also found that students who spent more time on social networking show adverse academic performance (Paul *et al.*, 2012; Kirschner & Karpinski, 2010).

Conclusion

The results of the study reveal that most students are addicted to the use of social media. It brings to light that a large majority of students strongly agreed that social media could improve academic performance if it is used in the right way. In contrast, the results also indicated that social media could affect academic performance according to females (53.33%) and males (22.00%) agreeing to it. The more time students spent on the internet would affect their academic performance however, the number of hours spent studying online on social media does affect academic performance as online learning is a good tool.

The results reveal that the younger age group are more involved in using social media than the above 30 years old. In addition, males have been using social media for a longer period than females and males spend more time on social media than females. Learners prefer WhatsApp (99.33%), Facebook (91.33%), Twitter (87.33%) and Instagram (83.33%) to spend most of their time on social media for the latest news, socialization and entertainment. On the other hand, females (8.5%) spent more time studying online compared to males (2.3%) and used social media for educational purposes more frequently than males. They believe that the use of the internet would improve academic performance and stated that social media improves their academic performance. In contrast, a positive correlation with the negative influence of social media does affect academic performance.

Lecturers and students can use social media as a teaching and learning tool to ease and improve learning process however, the students should be taught about the adverse effects of social media addiction, which may cause them to procrastinate and lose concentration on their academic activities. The institution of higher learning needs to adopt a new strategy for integrating social media tools into student teaching and learning. Using these tools for academic purposes would be relevant for our future generation to broaden their skills including content creation, problems solving, information seeking skills, analytical skills, motivating others towards a positive thinking, networking skills, updating knowledge skills, and dissemination of knowledge. There is a need for an awareness campaign among the students to promote social media networks as a tool not only for communication, entertainment and making friends but also for learning.

Acknowledgments

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Towards resilient manufacturing through smart technology strategies

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Abstract

The impact of the pandemic has led to the dearth of manufacturing systems resilience. Manufacturing industry leadership has discovered that traditional manufacturing processes are incapacitated by inefficiencies and bottlenecks in the current traditional manufacturing process. The pandemic has exposed weaknesses in traditional manufacturing processes, prompting the industry to seek ways to enhance productivity, efficiency, and sustainability. The emergence of smart technologies like IoT, AI, and robotics presents an opportunity to transform manufacturing and bolster resilience. This research paper focuses on teaching and learning within the context of manufacturing resilience. The study delves into the concept of resilient manufacturing and explores strategies for achieving it through smart technology integration. The research provides insights into how these technologies can effectively improve manufacturing operations' resilience, offering a comprehensive framework for their adoption. The goal of the research is to develop a manufacturing education framework that enables industry to implement strategies that can assist manufacturers to better respond to disruptions, minimize downtime, and ensure sustainability. The qualitative research explore and explain the impact of smart technologies on manufacturing, contributing to the enhancement of future work in the field of manufacturing education and learning.

Keywords: Technology, Manufacturing, IoT, Robotics, AI

Introduction

Applying a practice framework used in the design for manufacturing and assembly (DFMA) as a lens, the research paper reports on the application of mechanization in productivity improvement projects. When conventional productivity improvement tools and techniques do not yield the required results but instead produce disappointing results. Production engineering has to resort to measures that can alleviate the circumstance by introducing into production, mechanization through the application of production support auxiliary equipment (Adendorff et al., 1997). It is a responsibility of production engineering to continuously develop methods and techniques that will enable the production process to achieve responsiveness to productivity improvement stimuli.

Achieving responsiveness to productivity improvement stimuli is an ever-challenging task in the production industry (Narasimah et al. 2013) and (Hinckeldeyn et al. 2015). Thus, the scope for productivity improvement always exists and henceforth, there are alternative ways and means to achieve further productivity improvement, e.g., through mechanization of the production process. The use of mechanization techniques such as auxiliary production support equipment, jigs, fixtures, and spindles to increase the responsiveness of production to productivity improvement stimuli is widely documented. Notwithstanding, the extent and the depth of research in productivity improvement, there is very little literature on the design and application of other auxiliary production support tools and equipment.

Technically, a productivity dilemma occurs when conventional productivity improvement tools and techniques are applied in a production process and the resultant is an improvement in the production cycle time, but the process does not yield an increase in production output. Production cycle time is shorter due the improvement attained by applying conventional productivity improvement techniques, but the time saved is not significant enough to increase production output. This phenomenon is a case under study in this research paper, the research occurs in a rail locomotive maintenance operation, in which locomotive components are replaced during a maintenance-service production process. When conventional productivity improvement is engaged, the cycle time is reduced but it does not result into a significant increase in output.

The reason for the lack of output increase is that the amount of production time saved does not equal the time required to service one (1) extra locomotive. Therefore, although cycle time is improved, production output is not increased and thus there is no productivity improvement (Benzaquen, 2017). Productivity improvement is not achieved, since productivity generally refers to the amount of work that is accomplished in a unit of time, using the same input-factors, i.e., without increasing input-factors of a production process. Productivity improvement can also be achieved when the amount of work accomplished in a unit of time stays unchanged, while the input-factors are decreased (Shakeabukor et al., 2015).

Therefore, Production growth or productivity increase resulting from the increase in the volume of factor-inputs to a production process is limited and minimal by design as depicted in fig.1 below. When production inputs volume is increased from P1 – to- P2, the output growth increases from T1 –to- T3. T3 is not the maximum output capacity of the production system but it is the maximum possible through the increase in input-factor volume. Growth increase resulting from productivity improvement is a better option for production output increase, as depicted in fig.1. Output growth is greater when it is caused by productivity improvement, for the same input-factors, i.e., volume increase of P1 –to- P2. The resultant production growth caused by productivity improvement is T2 (see fig.1 below).

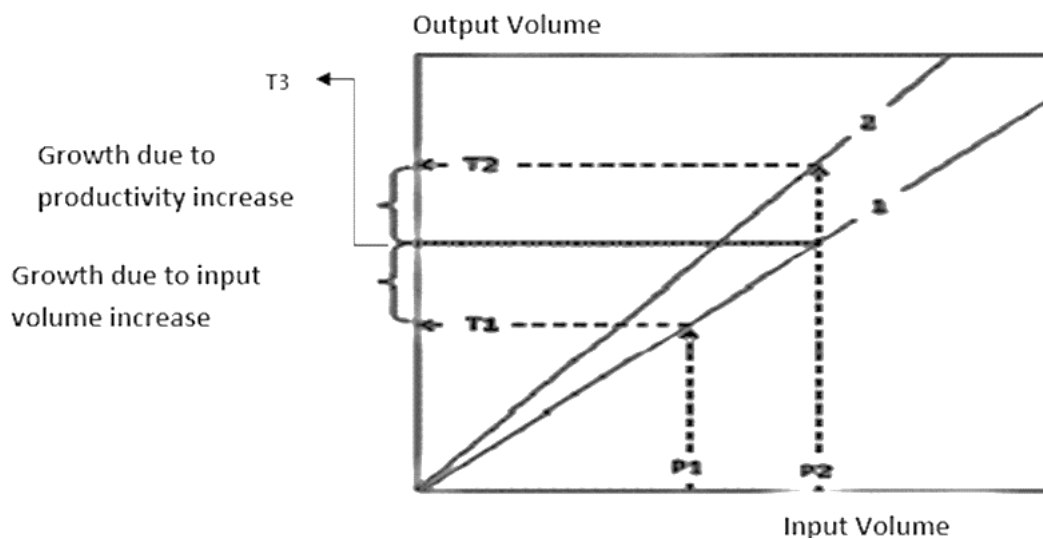


Figure 1; Component of Production Growth (Source: Saari, 2006)

The research presents a comprehensive example that illustrates the application of mechanization in productivity improvement initiatives, as a plausible panacea. Experimenting with the application of mechanization techniques such as auxiliary production support equipment, in productivity improvement culminates with a contribution to the body of knowledge with respect to productivity improvement. This research presents an investigation outcome in which production support auxiliary equipment are applied in a productivity improvement process and the resultant is an increase in output; reduced turnaround time; process optimization and productivity improvement. The application of production auxiliary equipment is studied, and the results produced are used as support to the presupposition that maximum productivity improvement can be achieved with the application of mechanization in production operations.

Results of this research in which mechanization is applied in productivity improvement initiatives in a rail setting, confirms the production efficiency theory. Production efficiency theory argues that any combination of input-factors of production at any point on a positively sloped isoquant is inefficient (Murillo-Zamorano, 2004), i.e., combinations of input factors to production where productivity increase is a result of an increase in either of the inputs or both. An efficient combination is only found on the negatively sloped portion of a convex isoquant (Murillo-Zamorano, 2004:34), where an increase in productivity is as a result of a decrease in either of the input-factors to production. This efficient portion is characterized by less quantity of the input-factors to production and the resultant is the same level of production output or higher.

Literature review

Productivity improvement is generally viewed in two broad levels, i.e., at a national level and at an organizational level (Macro- and Micro- respectively). At a national level, productivity reflects an economic view, while at an organizational level it reflects the level of profitability of the respective entity. Productivity improvement at a national economy level is the base for economic growth, national competitiveness, and an increase in standard of living (Kapyla et al. 2010) and (Nakamura et al. 2018). At an organizational level, productivity improvement is the efficiency and effectiveness of applying scarce resources used in the production process, and therefore productivity improvement at a micro- level is the critical success factor and the foundation of organizational profitability sustainability (Kapyla et al. 2010 & Kapyla et al. 2014).

In everyday practical and measurable terms, productivity is referred to as the ratio of output to input. It is also, referred to as the effective utilization of resources in producing goods and or services (Thomas & Sudhakumar, 2014). Production industry uses various and numerous measurement methods for productivity measurement. Nonetheless, there are two productivity measures that are commonly used. The two commonly used measures are total factor productivity (TFP) and partial factor productivity (PFP) (Thomas & Sudhakumar, 2014). TFP is defined as a ratio of total output to total input, with the latter comprising of labour, material, equipment, energy, and capital.

Partial factor productivity is a measure of a single or a selected set of inputs in Eq.1, and it is expressed as the ratio of output to a single input or selected set of inputs. A common example of PFP is Labor productivity, which is expressed a ration of output quantity to labour hours input. TFP is relatively difficult to compute but the measurement

process is easier and controllable than when a partial factor measure is used in the computation (Thomas & Sudhakumar, 2014).

In this research, PFP is measured for varying quantities of labour hours and a comparison of output for different labour inputs is done. Then the results are compared to the output of a technical change when auxiliary production equipment is applied. The law of returns to scale is a better example to use when experimenting with labour input for the calculation of PFP (Murillo-Zamorano, 2004:41) in a production and maintenance environment. The application of the law of returns to scale in the production industry where a PFP is calculated using variable amounts of labour hours and a constant capital input is depicted well using the consumer indifference curves or isoquants (Murillo-Zamorano, 2004). Isoquants are a firm's counterpart of the indifference curves (Murillo-Zamorano, 2004) see fig.2 depicted below:

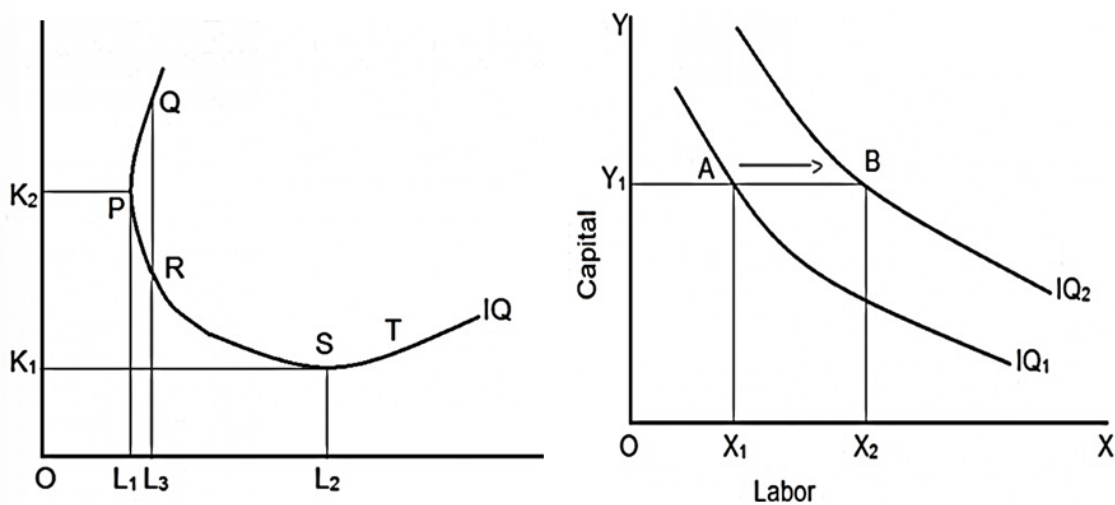


Figure.2: Production Isoquant curve and an Indifference curves map (Coelli et al. 2005)

The production isoquant curve depicted above in fig.2 fully illustrates the technological set of a production unit. A technological set captures all the production points with a minimum combination of inputs per output needed to produce a unit of production output. Therefore, all production input factor's combinations that outlines the unit isoquant PS are technically efficient (Murillo-Zamorano, 2004:34). Point P in fig.2 and all other points that settle above and to the right of the isoquant PS delineates a technically inefficient production input factor's combination. These points that are above and to the right of PS curve defines a technically inefficient producer since the input factors combination that is being used is more than enough to produce a unit of output (Murillo-Zamorano, 2004:34).

Mechanization of production and manufacturing equipment with the addition of auxiliary equipment improves the technological set of the production unit. To illustrate the relationship between input and output, in productivity studies, the use of a production frontier is appropriate since a production frontier represents the maximum production output attainable from each input factor level (Coelli et al. 2005). Therefore, a production frontier reflects the current state of technology in the particular industry and the technological set of a production unit. Henceforth and by implication, firms in the industry will operate on the production frontier, if they are technically efficient or beneath the frontier, if they are technically inefficient (Coelli et al. 2005). Figure3 is an illustration of technical efficiency or inefficiency using a production frontier.

Production operations at any point below the production frontier will yield lower productivity (Coelli et al. 2005) because any point on the frontier is a point of optimal technical scale and it can only be achieved by efficient technical change, which is only possible through the exploitation of economies of scale. Therefore thus, there is an additional source of productivity improvement called technical change (Coelli et al. 2005), which is possible through advances in technology that may be illustrated by an upward and to the right shift of an efficient production frontier. This improvement in productivity of the particular production unit is depicted by a movement of a production frontier OF_0 to OF_1 , see Figure3.

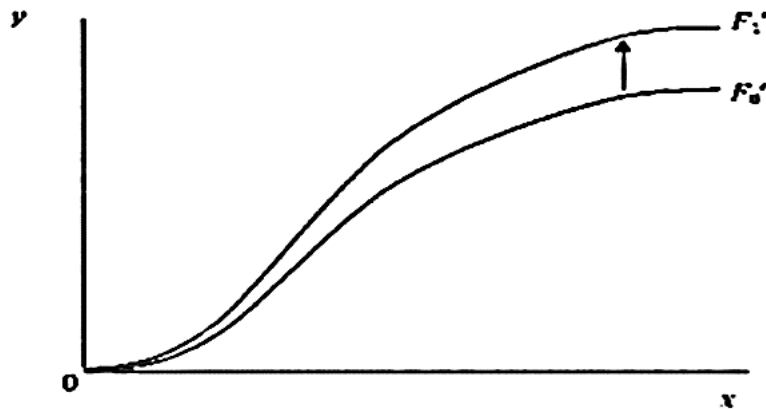


Figure.3: Economically feasible segment of a production Isoquant (Adapted from Coelli et al. 2005)

Mechanization of production with the aid of auxiliary equipment dates as far as the 1800. The introduction of a spinning mule by Roberts (1830) is one famous example of improving productivity with the aid of auxiliary equipment. Research on the use of auxiliary equipment in productivity improvement has been published various authors, e.g. in Girczyc and Carlson (1993), Boothroyd (1994), Anderdorff and De Wit (1997), Veerami (1997); Alpert (1998), Govil (1999), Cadwell (2000), Hermann and Chincholkar (2000), Kahng (2001), Bjornfot et al. (2007), Wiyaratn and Watanapa (2010), Narasimha et al. (2013), Kulkarni et al. (2014), Vashist (2014), Azar et al. (2015), Nithya & Saravanan (2015), Nakamura et al. (2018) and Fundin (2018). Nithya and Saravanan deliberates that the one aspect that improves the impact of new technology is an innovation.

Therefore, the notion that enhancing productivity is a key concern for almost all industries and that further productivity improvement opportunities always exist is plausible. Hence, production engineers are always inundated with research on ways and means of designing and fabricating production auxiliary attachments, jigs, and fixtures (Alpert, 2003). And constantly exploring production engineering methods that can further improve productivity, as proposed by Narasimah et al. (2013) and supported by Kamodkar et al. (2018). Henceforth, the use of auxiliary production equipment such as jigs, fixtures and other production support equipment is critical in productivity improvement. This research results is evidence of the impact of auxiliary production support equipment in productivity improvement initiatives.

Research method

In order to achieve the aim and objectives of the research and satisfy the requirements of the primary research question and the presupposition, a research paradigm is developed. This paradigm is used to explain the nature of the scientific truth, the theoretical framework, methodology and the data collection tools embraced in the research. The research question and the research presupposition require a paradigm that will enable the researcher to explore the definition of reality of the research and deliberate on the following questions: what and how is the knowledge acquired. The procedure, tools and techniques used to acquire this knowledge, and the data collection process used is explained.

This research adopts a qualitative research approach because it enables researchers to establish an understanding of the phenomenon from the perspective of those experiencing it (Baxter & Jack, 2008) and (Flick, 2018). The shared purpose of qualitative research studies, depicted by Baxter & Jack (2008), increases the plausibility of adopting qualitative research methodology. Subsequent, to adopting a qualitative research approach for this study, numerous qualitative research methods are considered and analysed (e.g., Phenomenology, Grounded Theory, Ethnography, Participatory Action Research (AR), Hermeneutics, Case Study, Narrative, Evaluation Research (PAR), Observation, etc.). Thus, this research is poised to focus on a qualitative research approach, using action research methodology (AR) and a case study method.

The hallmark of a case study method is the use of multiple data sources (Yin, 1994 & 2018, and Patton, 2002), which is a strategy that enhances data credibility (Patton, 2002 and Yin, 2003). This case study will employ the following triangulation of data sources: i) document analysis and archival records analysis; ii) Journal publications and field notes analyses; iii) production process observation and analysis through SREDIM. A combination of data sources and data collection methods in a study of a single phenomenon enables researchers to draw upon multiple sources of evidence and therefore, enables them to seek convergence and corroboration, through the use of different data sources credibility (Patton, 2002 and Yin, 2003). The culmination of a triangulated data capturing approach is a holistic picture of the case under study.

In this qualitative action research case study, data is collected through a triangulation of qualitative research data collection tools. The tools employed are i) the analysis of archival records and document, ii) An analysis of field notes of other researchers and an extensive review of journal publications, and iii) the observation and analysis of the production process is through SREDIM method. SREDIM is an acronym for Select, Record, Examine, Design & Develop, Implement, Monitor, and Manage.

Discussion

The maintenance demand plan requires eight (8) locomotive components replacements (i.e., 4 electric and 4 diesel) per day. The capacity of the production line is four (4) components replacement per shift of 9 hours. When an overtime of three (3) hours is added per shift (Total shift hrs = 12), production output increases by one (1) component changeover and the total output becomes five (5) locomotive lifting activities in a shift. In order to satisfy the demand and enable the production line to attain an output of eight (8) locomotives per shift, productivity improvement is indispensable. The complexity of productivity improvement in the rail industry (and heavy industry in general) is born out of the fact that it is almost impossible to increase the number of the infrastructure,

equipment, and resources, quickly enough to improve production output, without incurring high costs.

Numerous conventional productivity improvement techniques were applied (e.g. Lean, six-sigma, TOC, Time and method study) in an endeavour to increase production output and meet the current productivity improvement target, i.e. eight (8) component replacement per shift. Output is increased when production cycle time is reduced, meaning more replacements are done in the same production shift. Thus, the production process is studied, production process analysis is applied, method analysis is initiated, and the resultant is a production process method improvement. Method improvement leads to shorter cycle times that lead to an increase in output, and therefore, productivity improvement.

As stated in the methods section, in order to attain the productivity improvement endeavoured and the required demand planned output of eight (8) components replacement per locomotive maintenance shift, a time and method-improvement study technique is applied. First, A process analysis method is applied on the current component replacement production process as a selected case study unit for this research. Second, the “As Is” production process is recorded and a process flow of the current production activities is established (see fig.1). Third, The “As Is” or current production process is examined through the application of time and method study techniques, the resultant is an identification of process waste and unnecessary motion and storage. Fourth, Method Analysis is applied in order to develop an easier, simpler, more efficient, and a cost-effective working method (see fig.2).

Based on the results of a method analysis, a process improvement technique is applied to improve the production operations process by reducing non-value adding activities and removing waste (see fig.3). The resultant is a better utilization of resources, i.e., capital, personnel, and equipment. Fifth, when the improvement achieved with the application of time and method study does not yield the required target productivity and a technology innovation is applied to the maintenance production process. Then an improved future-state production process is established. Sixth: The new production process is monitored and managed to maximize production output and for continuous improvement. Thus, method improved is applied to the new maintenance production process.

Results

Application of Smart manufacturing techniques such as Mechanization leads to an optimization of the production maintenance process and a higher production yield is obtained. Results of mechanization of the production maintenance process display a shorter process cycle time and better efficiency in the new production process. Improved efficiency of the new method refers to less non-value adding operations and less waste, and an increase in the total operations efficiency. These results mean that the new maintenance production process (TM replacement process) is better optimized than the ‘as is’ production process. Therefore, the new TM replacement process is more efficient than the old locomotive lifting production process. Better process efficiency means the inputs of a production process are better utilized and the resultant is an increase in output, and therefore an improvement in productivity of the production process.

















Process	Symbol	Tally	
Position Loco over the removable track		1	
Place hydraulic piston jerk on the track		2	
Place a bracket on the hydraulic piston jack		1	
Loosen and remove all bolts holding the TM		2	
From under the loco, in the pit, position a lever for TM lifting		3	
Tilt the TM to an angle and Let it slide out of the bogie		4	
TM falls into bracket, lowered and removed		3	
Holst out the TM with crane and transfer to the repair store		4	
Exchange TM and transfer the new to assembly		4	
Place traction motor into the bracket on the piston jack		5	
Raise TM to mounting position		6	
Tilt the TM to an angle and push it into position in the bogie		7	
Replace all traction motor bolts and secure it		8	
		Total	%
Symbols Key			
Operations		8	62
Transport		4	31
Storage		1	7

Figure4: Method Improvement of the new production process (Source: Author)

Results of the method analysis of the new production process demonstrate that the new process has a high percentage of value-adding process activities as compared to the improved “As Is” production process. Therefore, to assess the efficiency of the new production process (TM replacement) an application of a method improvement technique was instituted on the new TM replacement production process (see fig.4). Results of this process improvement initiative demonstrate a 25% reduction of wasteful operations activities, 18% reduction in non-value adding movement and an elimination of storage within the production process. The new production process cycle time is 1hr to complete a TM replacement (compared to 2hrs of “AS IS” process). The method improvement exercise culminated into a reduced production cycle time and an improved efficiency of the new production process.
















Process	Symbol	Tally	Modification
Position Loco over the removable track		1	Set up
Place hydraulic piston jerk on the track		2	Set up
Place a bracket on the hydraulic piston jack		1	Set up
Loosen and remove all bolts holding the TM		2	
From under the loco, in the pit, position a lever for TM lifting		3	
Tilt the TM to an angle and Let it slide out of the bogie		4	
TM falls into bracket, lowered and removed		3	
Hoist out the TM with crane and transfer to the repair store		4	Set up
Exchange TM and transfer the new to assembly		4	Set up
Place traction motor into the bracket on the piston jack		5	
Raise TM to mounting position		6	
Tilt the TM to an angle and push it into position in the bogie		7	
		Total	%
			Improved Process
			Total
			%
		8	62
		4	31
		1	7

Figure5: Process Optimization process results through the application of Mechanization (Source: Author)

Application of Smart technology techniques such as Mechanization on the new production process (TM replacement) yields an optimum and maximum production and operation process productivity. Operations efficiency is improved by 25%, transport is reduced by 18% and storage is completely eliminated in the new production operations. Production cycle time is reduced from 2hr to 1hr, through an improved utilization of production resources. These results will increase product output and therefore, total productivity of the production operations process. Analysis of production output data (in table 3 below) demonstrate the impact of the application of auxiliary equipment in productivity improvement initiatives as positively high. The impact of the application of Mechanization on production, through support auxiliary equipment in productivity improvement is vividly demonstrated in the productivity improvement data table (see Table.1).

Table 1: Production Output Optimization Statistics resulting from Mechanization.

Analysis Theme	'As Is' production process		Productivity Improvement		Application of Auxiliary equipment	
	HRS	Output	HRS	Output	HRS	Output
Normal Shift	9	4	9	5	9	8
Over Time	3	1	3	1	3	3
Night Shift	12	5	12	6	12	11
Total	24	10	24	12	24	22
Increase in productivity						
	%	0	%	20	%	120

In table.1 above, the 'As Is' production process has an output of 10 TM replacements in 24Hrs. When productivity improvement techniques are applied to the 'As Is' there is a 20% productivity improvement on output. Therefore, the total output in 24hrs is increased by two (2) components replacement, which becomes 12 in 24hrs. When auxiliary production support equipment is applied in productivity improvement, the resultant total output improvement is a 120% productivity improvement. Note that with the application of auxiliary production equipment (Mechanization) the production process output is 11 in a 12 hrs shift (22 in 24hrs). Therefore, the demand plan target is achieved. Productivity improvement experienced also alludes to an increase in efficiency, and the reduction of waste and non-value adding activities, when Smart technology is applied (see fig 5).

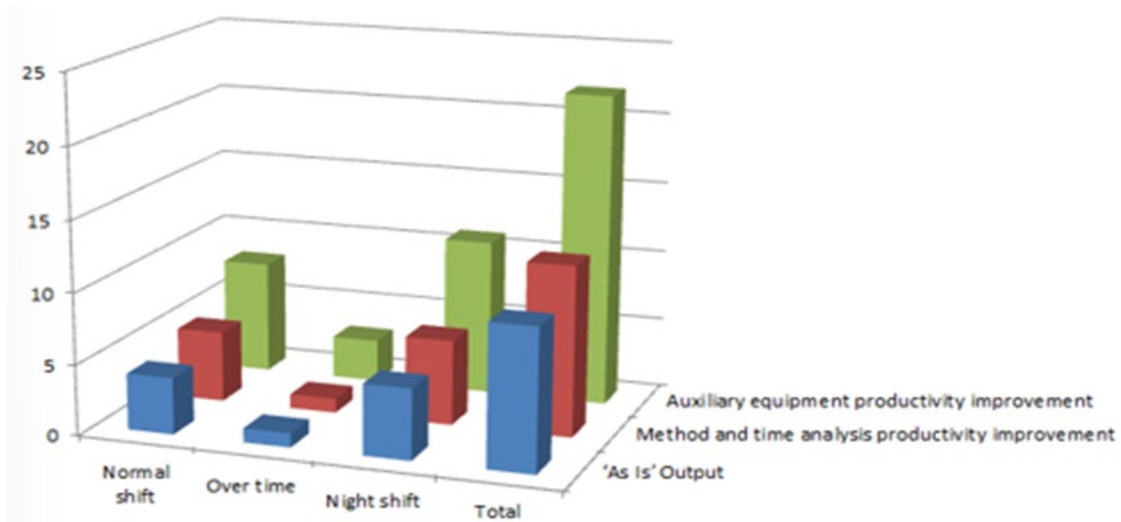


Figure6: Production Results for different intervention in a shift (Source: Author)

The graph in fig.6 demonstrate an intrinsic examination of the interrelationships among variables within each case of the study. Therefore, engaging a comparison across cases, in search of patterns and similarities, reveals an elementary establishment of a phenomenon displayed, that is, the variable 'over time' output remains the same across the two cases, although there is a productivity improvement of 20% in one particular case.

Thus, it can be broadly generalized that not all process improvements will yield an increase in output. Based on a generalized definition of productivity that it concerns with the ratio of output to an input, the interrelationship between the variable (Over time) within the case (Method and time productivity improvement) disconfirms a competing postulated presupposition that all productivity improvement will result in an increase in output.

Conclusion and recommendations

An intrinsic examination of the interrelationships among variables within each case and engaging a comparison across cases, in search of patterns and similarities, reveals an elementary establishment that the results obtained in un-optimized productivity improvement activities are a reflection of the limitation inherent in productivity improvement tools and techniques in a particular industrial setting (as seen in table 3). The industrial setting in the railway maintenance operations is rigid and not dynamic, therefore the output of conventional productivity improvement initiatives falls short, and productivity achieved is less than the maximum possible output. This is a case where conventional productivity improvement techniques produce disappointing results.

It is established that with the help of a systematic study of all the critical attributes of the limitation of conventional productivity improvement techniques and the application of work-study method, the desired maximum and optimal improvement in productivity can be achieved. This is true with the application of auxiliary support equipment in productivity improvement initiatives. The application of auxiliary production support equipment in productivity improvement projects is highly advantageous, owing to its capability to simultaneously increase total production output and exponentially improve percentage growth in productivity (as demonstrated in table.3 and fig.7 below). It is clear that the application of auxiliary equipment, in productivity improvement initiatives, has a huge impact on the production cycle time.

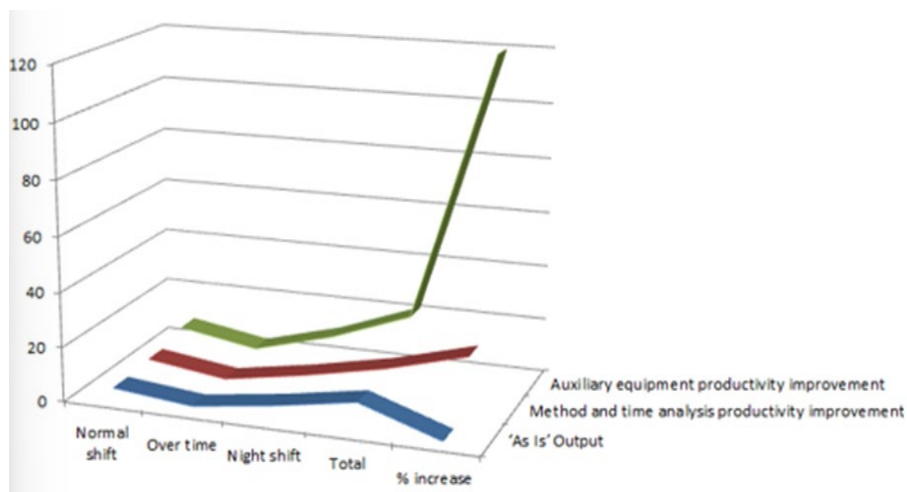


Figure7: Productivity Improvement Results through Smart Manufacturing (Source: Author)

It is thus apparent that the size of the time value-add produced in productivity improvement initiatives is proportional to the output yield. Productivity improvement yield is higher in the case where auxiliary equipment is applied in the productivity improvement initiative. The total output yield is higher for the auxiliary equipment case as depicted in figure 7 and the percentage increase is the highest of all the productivity

interventions. Application of auxiliary production equipment in productivity improvement demonstrate its capability to simultaneously increase total production output and exponentially improve percentage growth in productivity (as displayed in fig.7). It is clear that the application of auxiliary equipment, in productivity improvement initiatives, has a huge impact on the production cycle time and therefore on the production output and consequently on productivity.

Therefore, it is apparent that it is crucial to underscore the significance of incorporating the design of jigs, fixtures, and auxiliary production equipment into our manufacturing and production educational and learning endeavors. The impact of the pandemic has underscored the importance of resilience in manufacturing, and the integration of smart technologies has opened up new avenues for improvement. However, we must not overlook the fundamental building blocks of manufacturing processes and teaching and learning.

The design of jigs, fixtures, and auxiliary production equipment forms the backbone of efficient manufacturing systems. These tools and equipment enable precision, repeatability, and consistency in production, contributing significantly to the overall quality and efficiency of manufacturing processes. Inclusion of this aspect in manufacturing education is essential to equip future professionals with the skills and knowledge necessary to optimize production operations.

By integrating the design and utilization of jigs, fixtures, and auxiliary production equipment into our educational curricula, we ensure that our students are well-prepared to address real-world manufacturing challenges. This practical knowledge empowers them to not only harness the potential of smart technologies but also to maximize the benefits of these technologies by seamlessly integrating them into existing manufacturing systems.

Moreover, by focusing on these foundational aspects of manufacturing, A framework that enable the industry to cultivate a workforce that can adapt to various manufacturing scenarios, from traditional to advanced technologies, is established. This adaptability is key to building resilient manufacturing systems capable of withstanding disruptions and ensuring sustainable production.

The future of manufacturing education and learning must embrace a holistic approach that encompasses both cutting-edge technologies and the enduring principles of efficient manufacturing. By emphasizing the design of jigs, fixtures, and auxiliary production equipment, we lay a solid foundation for the continued growth and innovation of the manufacturing industry, producing skilled professionals ready to meet the challenges of the future.

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Application of big data, machine learning, and artificial intelligence strategies in healthcare data processes optimization

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Abstract

Public health care delivery is dynamic due to the growth in health care science and research in health care delivery systems. The rise in the application of the Internet of Things devices led to an unprecedented increase in data generated. The level of data produced within a healthcare system is vast and that has generated a greater need to begin applying big data analytics strategies and methods to establish data and information quality. Process optimization and productivity improvement in healthcare service delivery pivots prominently on the quality of information available within the system. Thus, in a process of increasing throughput and reducing patient cycle time throughout the patient journey in a hospital, there is a desperate need for the application of intelligent tools for accuracy and believability assurance in information generated for management decision making. This paper describes a data processing improvement event achieved through the application of big data strategies in the patient affairs and data management faculty of a public hospital. In this research a data driven approach to patient information management is adopted and data capturing is transformed from a paper-based to paper-less system. A qualitative research approach is adopted in the case study.

Keywords: Healthcare, IoT, Optimization, Productivity, Big Data.

Introduction

Increasing demands of the economic, social, demographic, and political status quo in South Africa (SA) creates pressure on public health care (PHC) provision resulting in an emerging need for efficiency and effectiveness that fosters the use of productivity improvement methods, tools, and techniques. Specific to PHC is the application of big data processing tools and techniques, which are traditionally, applied in sectors such as manufacturing and logistics. The most plausible tools, techniques, and productivity improvement methods applicable in PHC are process improvement methods (Joste et al., 2009).

Public healthcare facilities are among the most complex public sector institutions (MacFarlane et al., 2005), that requires the implementation of private sector management paradigms. To improve the service system, this article describes how big data methodologies can benefit and improve care processes in a complex hospital environment (Bentahar, 2018). The basis of this rigorous improvement approach outlined is a scientific method, and the integration and implementation of various big data tools and techniques, in an environment that is traditionally synonymous with adherence to outmoded and inefficient management models (Hilbert, 2011a).

It is therefore apparent that there is room for improvement with-regards to the following operational dimensions, i.e., quality, efficiency, and cost effectiveness (Jooste et al., 2009). It is critical to note that due to the complexity of operations in a hospital, a very elaborate approach for care service improvement is indispensable. The approach implemented must be able to integrate methodologies across a multitude of disciplines,

i.e., process improvement, data analytics and operations management, within the context of a medical profession (MacFarlane et al., 2005). Therefore, modern information and communication technology (ICT) tools are predisposed to succeed because they function along and across multiple functional dimensions.

Analysis of a care delivery journey in public health care facilities reveals that care service delivery performance measurement are critical for the hospital. There are many service delivery performance indicators in a hospital, the main indicators are: Length of stay (LOS); Leaving without being seen (LWS); Dying without being seen (DWS); and Dying after being seen (DAS). A common denominator for all these performance measurements is time spent in the care process (Han et al., 2010). There is a huge database on service time and total turnaround time in a healthcare facility and thus patient waiting time is one of the critical measures of care delivery process performance.

Due to the complexity of care facilities, in particular a hospital, care delivery must adopt a strategy that enables the application of scientific methodologies, and a fusion of core ICT faculties such as data management, Operations Research; Operations management; and information Systems management. In addition, Joosten et al. (2009) highlights the need to apply these disciplines in a scientifically sound method that is supported by actual data, observations, and empirical evidence. Therefore, a fusion of a variety of disciplines and an application of a scientific methodology in gathering supporting field data is required (Rogg et al., 2013).

A cursory view of the care delivery operations in a hospital reveals the hospital management systems dilemma (Rowe et al., 2011). That of the difference between work-as-imagined (WAI), which is what designers, managers, regulators, and authorities believe happens or should happen, and work-as-done (WAD) which is what actually happens in the workplace. The impact of the management system dilemma, manifest as care-delivery-process underperformance because WAD reflects performance variability that underlies successful execution of work on the hospital floor (MacFarlane et al., 2005).

Therefore, The Gap experience between WAI and WAD is a result of hospital operational systems complexity and not the fault of hospital personnel performance (MacFarlane et al., 2005) . Patient affairs department, patient data capturing, and administration are the first point of contact for a hospital. Thus, there is usually overcrowding in these sections of the hospital and this an apparent indicator that the service delivery process is not performing optimally (Jansen, 2010).

Overcrowding in the hospital is due to an extended patient's length of stay (LOS). This means patients spend more time in the system than it is necessary. The reason for this extended LOS is primarily a system failure or a bottleneck. The percentage of incoming patients is far less than the percentage of outgoing patients in the care service system. This system failure leads to a myriad of challenges affecting the entire hospital, which perpetuates overcrowding and congestion.

This paper is organized as follows: Section 2 is the background of the study, which is a detailed explanation of the environment in which the research takes place. Section 3 is the literature review, with a focus on the current dynamics of public healthcare. Section 4 is a discussion of the methodology and approach of the research. Section 5 is a

discussion of the value derived from applying big data practices. Section 6 concludes with a summary and managerial implication of the improved PHC, and section 7 elaborates on areas of future research.

Background

Data depositories exist in many forms in a public hospital, primarily, public healthcare employs a paper system that comprise of a brown cover file with a large number of loose pages containing patient information. Some data pockets are stored electronically and both paper and e-data is unstructured and difficult to use. Most of the files are in a big room for storage and are retrieved when required. The archival method in these rooms is normally not systematic or methodological. Files are kept in boxes and boxes packed haphazardly all over the storeroom.

The method applied for storing data has raised significant ethical and legal challenges. These challenges range from risks for individual rights, privacy, and autonomy, to transparency and trust. Since the hospital is finding it difficult to store and manage data, management has contracted a private 3rd party company to manage and archive hospital data. The company has a better archival system, and it is largely an electronic archival system. Albeit the data stored is still unstructured and difficult to use for management decision making.

The lack of funds and other public entity inherent mediocre attributes has exacerbated the data management issues, in that the private company utilized to store data has denied the hospital access to the data stored because they are not paid the required storage rental costs. Therefore, the hospital has no access to the patient data history, this led to the mushrooming of paper files again and a data storage dilemma. The dilemma is characterized by multiple files per patient and the unavailability of historical data needed for the patient treatment process. It is also the main source of the hospital care delivery system failure and a basis or a springboard for service process limitations and subsequent failure.

The absence of good data management systems leads to medical administration challenges such as wrong diagnosis and patient follow-up process failure. Disadvantages of the lack of an archiving system range from difficulties to collect revenue, increased litigation, care delivery system failure, disgruntled hospital communities and underperforming hospital service processes. The absence of a data management system is derailing the total productivity of the hospital and the need for data process optimization is apparent. Enterprise risk management for business continuity is also hindered by the lack of a data backup system and therefore future planning and productivity improvement is impossible in the entity.

Literature review

In recent years, the healthcare industry has been generating massive amounts of data from various sources, such as electronic health records, medical imaging, patient feedback, and wearable devices. Analysing this vast amount of data can help healthcare organizations to improve patient outcomes, enhance operational efficiency, and reduce costs. This literature review aims to explore the current state of research on the application of big data strategies for healthcare process improvement in a hospital.

In a literature review study by Wang et al. (2018) a proposal for a big data-driven framework for optimizing emergency department (ED) operations is suggested. The study demonstrated that the framework could significantly reduce patient waiting times and improve overall ED performance. Similarly, a study by Aguirre et al. (2019) used big data analytics to optimize patient flow in a hospital's emergency department, resulting in a 25% reduction in wait times.

Another study by Denecke and Gabrys (2016) applied big data analytics to predict hospital readmission rates. The study used machine learning algorithms to analyse patient data and identified several risk factors that were associated with readmission. This information can be used to develop targeted interventions that can reduce the likelihood of readmission. In addition to improving patient outcomes, big data analytics can also help healthcare organizations to reduce costs.

A study by Sun et al. (2018) used big data analytics to identify cost-saving opportunities in a hospital's supply chain. The study found that optimizing the inventory management system could result in significant cost savings. Last but not least, a study by Shah et al. (2019) examined the use of big data analytics for population health management. The study demonstrated that big data analytics could be used to identify high-risk populations and develop targeted interventions to improve their health outcomes.

Application of big data strategies for process improvement in healthcare has shown promising results. Big data analytics can help healthcare organizations to improve patient outcomes, enhance operational efficiency, and reduce costs. However, there are still many challenges that need to be addressed, such as data privacy concerns, data quality, and data integration. Further research is needed to address these challenges and explore the full potential of big data analytics in healthcare.

A cursory view of the care delivery operations in a hospital reveals the hospital management systems dilemma. That of the difference between work-as-imagined (WAI), which is what designers, managers, regulators, and authorities believe happens or should happen, and work-as-done (WAD) which is what actually happens in the workplace (Holroyd et al., 2007). The impact of the management system dilemma, manifest as care-delivery-process underperformance because WAD reflects performance variability that underlies successful execution of work on the hospital floor (Han et al., 2010).

The Gap experience between WAI and WAD is a result of hospital operational systems complexity and the current healthcare service processes execution (Han et al., 2010). Knowing that individuals and organizations always adjust to the prevailing conditions and the contextual constraints of the current moment, as postulated by Gottschalk et al. (2006), this research had to first remedy challenges derived due to the time element of the patient care delivery journey. Therefore, the focal point of the research had to be the patient data administration, which is the first contact point of the patient and the hospital (Imperato et al., 2012).

Research method

Qualitative case study methodology affords researchers opportunities to explore and explain a phenomenon within its context using a variety of data sources (Baxter & Jack, 2008). This approach ensures that the phenomenon under study is explored through a

variety of lenses which allows an in-depth understanding and allows multi facets of the case under study to be revealed and understood (Patton, 2002). The case study approach aligns to the goals of the research in that the focus of the study is to explore and explain the application of big data strategies in PHC, and it covers the contextual conditions in which the phenomenon under study occurs.

The rationale of the research is that the application of intelligent tools for accuracy and believability assurance in information generated for management decision-making, will improve care delivery processes in a hospital. Thus, the research appeals to boundaries stipulated by Creswell and Charmaz et al., those of time and place (Glesne, 2011). In line with the boundaries of definition and context, and the research question (Can big data strategies improve patient information management in a hospital?). The type of case study this research adopts aligns with explanatory and exploratory or descriptive case study as categorized by Yin (1994). Thus, data has to be processed with advanced tools to generate decision enabling information process optimization.

Yin (1994) and Patton (2002) stipulate that a hallmark for case study research is the use of multiple data sources, which is a strategy that enhances data credibility (Petty et al., 2012). This case study will apply the following triangulation of data sources i) document analysis and archival records; ii) field notes and journal publications; and iii) process observation. The combination of multiple methods in the study of the single phenomenon enables a researcher to draw upon numerous sources of evidence and, to seek convergence and corroboration through the use of different data sources. Therefore, credibility is achieved for evidence drawn and decisions or solutions established for the research problem.

These data collection methods enables the researcher to observe theory-in-action rather than espoused theory, an observer is able to write a description of what is observed and then develop a theoretical framework to help explain the process or phenomenon observed. In this context, that is manifested credibility (Patton, 2002), and Yin, 2003). It is therefore rational to apply these methods as a data collection tool in this research, particularly the application of informal participant observation. Robson (2013) alludes to the fact that it is typical for qualitative studies to use informal participant observations where data comes from interpretations of what is observed (Baxter & Jack, 2008).

Therefore, the research applies these data collection tools to capture the ‘As Is’ status in the hospital and facilitate the transformation from the current state to a more optimized future state. Leveraging vast amounts of patient data, electronic health records, and medical research, the hospital employ advanced analytics and machine learning algorithms to gain insights into patient populations, treatment outcomes, and healthcare processes. These insights help in identifying trends, patterns, and areas for improvement. This data-driven approach enables the development of predictive models for disease prevention, early diagnosis, etc. Therefore, in essence, big data strategies empower healthcare systems to evolve from their current state to a future state that is more efficient, effective, and patient-centric.

Data management optimization project

The first step of optimizing care delivery data processes through the application of data analytics is a decision on data governance, that is, decisions about how data is sourced, cleaned, managed, distributed, and used. Then the current state logical architecture is

compared with the desired improved future-state logical architecture, the sole purpose is to close the gap that exist. The future-state is an updated and improved logical architecture for the to-be big data structure. The data architecture is amended with the new structure and the connecting points between the new structure and the current structure are established. Then, the method of data integration is established.

The two methods of data virtualization, i.e., leaving data in place and providing the means of doing federated queries and data integration, which are required to move data from one environment to the next for processing, are applied. A system approach is adopted (see figure.1) and the four areas of a system environment are profiled in a data source profiling exercise. Given the lack of a schema, profiling source data is akin to data modelling. The four system areas are depicted below in Figure.1. Data profiling is done to ensure a quality data processing, because without an anticipation tool, data processing cannot be credible enough to continue.

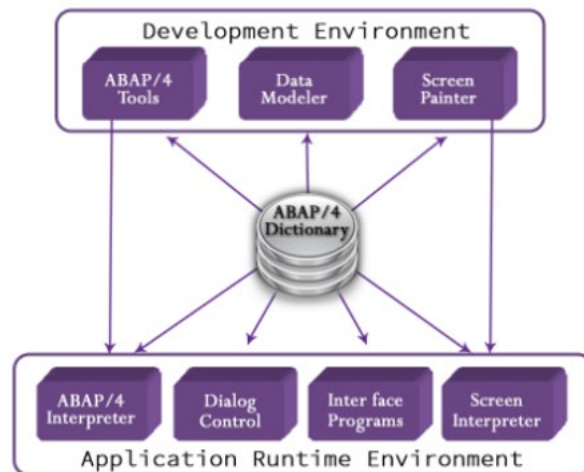


Figure1: Data System Views. Information Theory Diagrams (Adapted from Hilbert, 2011a)

Once the future state has been modelled and the desired improved logical architecture envisioned is visualized, data transformation is engaged. Data transformation is done within a structured approach that recognizes the four pillars of big data transformation (see figure.2). These are user support and operation procedure design; information security design; data integration logical design, and user interface design. Application/integration is a component of user support and operation procedure design; Information/data is a component of data integration logical design; Technical/infrastructure is a component of information security design and business architecture is a component of user interface design.

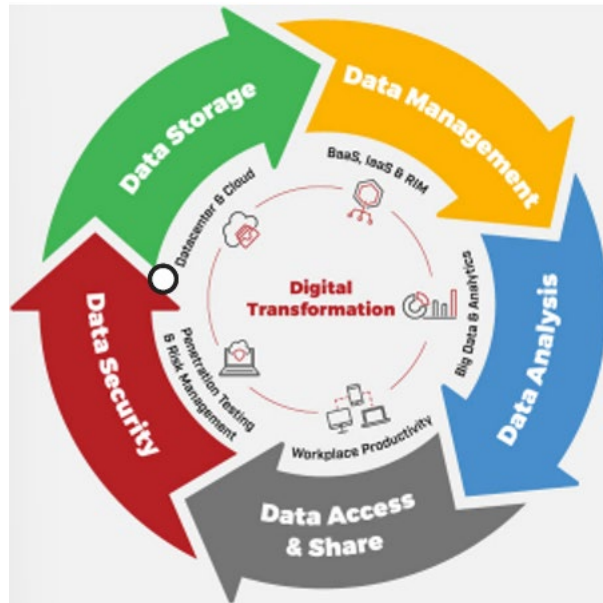


Figure2: Data Transformation Structured Approach

The project of applying big data strategies for Data management process optimization is approached and engaged in a hierarchical structure. First, a technology approach is adopted, i.e., technology such as a computer system is used. Secondly, a big data strategy such as data analytics is applied and application such as software tools are used. Thirdly, a governance structure is adopted i.e., a decision on how data is collected, organized, secured and distributed is adopted and operationalized. Fourth, Business data process improvement is applied, and a future-state logical architecture is established (see fig.3).

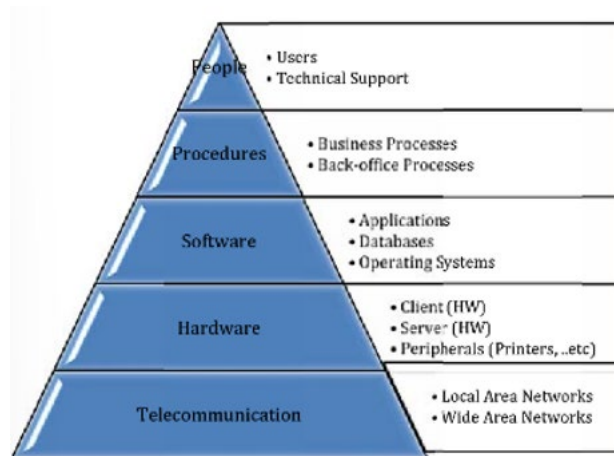


Figure3: Hierarchical Structure for user support and Operation Procedure Design
(Adapted from Hilbert et al. 2011)

The research project is operationalized by adopting the Lean systems approach, in which lean practices are used to eliminate redundant data entry tasks, reduce errors, and improve data accuracy. The approach leads to improved data management by emphasizing continuous improvement, standardized processes, and the elimination of non-value-added activities. The old archives were transformed by converting them from a paper-based system into an electronic system. The physical data storage is transformed

into an e-data storage by scanning patients' medical records and storing the data electronically.

The scanned data is stored in the main computer into which it was scanned and then data is transferred into the main server. Governance is applied for retrieval and usage and the patient administration process is transformed from a paper-based system to a complete electronic process. Using big data analytics, system application processes are set to enable validation and information quality e.g., all files have a consistent filing protocol and numbering system. Thus, with the new system, there is one file per patient and patient data is cleaned and backed up. All categories of patient information are in one file and retrieval is based on information security protocols and data governance principles.

Discussion

The newly implemented data storage and archival system has a positive impact on the patients' medical service delivery process in that there is not duplication of information, patients' information is not mixed or misplaced or lost. It is quicker for medical staff and admin clerks to retrieve information and use it productively. Therefore, the turnaround time for a patient at any point in the process of patient affairs is reduced drastically. There is no congestion in the process as bottlenecks are eliminated or moved to areas with less impact by streamlining patient data capturing and retrieval protocols in the care service delivery process.

Big data analytics improved information believability, credibility, validity, and quality. Data organization has led to quality information for management decision making, and the quality decision made is seen in the quality of service provided. Cycle time for care service delivery has been reduced and turnaround time improved, there is an increase flow at all patients' administration service points. Request for information from patients' data are quickly done and quality information is presented in a way that will enable better medical treatment decision, based on historical events in the files.

The process of delivering care service in the hospital is fast, smoother, and better in terms of the quality of service, the time spent in the service process, the turnaround time, and the high level of adherence to care delivery service principles as prescribed by the national core standards (NDH, 2007). Through the application of big data tools and data integration for better decision-making using machine learning protocols, care delivery process failure has been eliminated and litigation is reduced to a bare minimum. Staff morale has improved, and the serious adverse events (SAE) have been reduced drastically. This approach to data management structure transformation has led to better decision making, enhanced patient outcomes, and increased cost effectiveness within the hospital care delivering systems.

Conclusion

It is evident that data management can create a bottleneck in a system and therefore hinder the rollout of a process used to deliver a service. Data generated in healthcare systems is unstructured and difficult to store and retrieve for usage, this is a typical big data attribute, thus healthcare system data requires big data strategies to manage and use productively. When big data strategies are applied, the architecture of business information is improved and thus the quality of information is improved, high quality decision are enabled. This leads to an improvement and an optimized care delivery process in a hospital.

The research has highlighted the transformative potential of applying big data strategies in healthcare service process improvement, particularly in hospital settings. The literature review demonstrates that the application of big data analytics has shown promising results in optimizing various aspects of healthcare delivery, from reducing patient waiting times and improving patient flow to predicting readmission rates and identifying cost-saving opportunities in the supply chain. Additionally, big data analytics has proven effective in population health management.

A qualitative case study research approach applied allows for a comprehensive exploration and understanding of the application of big data strategies and techniques in healthcare service process execution. The research approach involved multiple data sources, including document analysis, field notes, journal publications, and process observation, ensuring data credibility and enabling the observation of "work-as-done" in contrast to "work-as-imagined" in a data driven healthcare delivery service system. The discussion presents compelling evidence of the positive impact of big data strategies and tools on patient information management in a hospital.

The implementation of a new data storage and archival processes and system has significantly improved the efficiency and accuracy of patient care delivery processes. The reduction in duplication and errors, faster data retrieval, and improved data quality have resulted in enhanced patient outcomes and reduced litigation risks. Moreover, the application of big data tools and data integration has led to better decision-making, cost-effectiveness, and increased adherence to healthcare standards. However, it's essential to acknowledge that the successful implementation of big data strategies in healthcare service systems is not without challenges, such as data privacy concerns, data quality issues, and the complexity of healthcare operational systems.

Addressing these challenges will be crucial for realizing the full potential of big data strategies and tools in healthcare service delivery systems. Findings presented in this study underscore the transformative power of big data strategies in healthcare service delivery systems, offering the potential to revolutionize patient care, improve operational efficiency, and reduce costs. As healthcare organizations continue to navigate this data-driven landscape and the integration capability of machine learning, further research and ongoing efforts to address challenges will be vital to harness the full benefits of big data strategies in healthcare delivery.

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What happens to the photos they take? An investigation into how programming students utilize photographs taken during lectures at a South African private higher education institution

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Abstract

The ubiquitous nature of mobile devices equipped with high resolution cameras has resulted in a phenomenon increasingly observed as higher education institutions continue with face-to-face classes. Particularly when technical aspects are covered in class, it is becoming more noticeable and prevalent that instead of writing study notes or typing up code from a projector screen, programming students resort to taking photographs of lecture slides, lecturers' code, diagrams on the screen, or even assigned in-class activities.

Whilst this phenomenon has been explored in several contexts and disciplines, the context of programming education in a developing country remains largely unexplored.

Utilizing the case-study approach, supported by a focus group discussion, comprising purposively sampled programming undergraduate students, this paper sought to understand how programming students utilize the photographs they take in class. Additionally, this paper explored the reasons behind students opting to photograph lecture content as opposed to writing or typing out notes, and the perceived benefits and challenges associated with this practice. The findings indicate that students take photographs of content that they deem important for future use, refer to content that they have generated when working on their own, use photographs to work on assessments, and even develop sharing networks with peers.

The HSGC framework recommended by this paper can equip lecturers and institutions with a greater understanding of how to effectively accommodate students who harness the opportunity to generate their own content on their smartphones.

Keywords: educational technology, higher education, smartphone photography, programming education, SAMR

Introduction

There is no doubt on the pervasive ubiquitous nature of mobile devices across the globe. In the South African context, the number of smartphone subscriptions were placed at 73.8 million subscribers in 2022, outweighing the South African population (ICASA, 2023). Furthermore, South Africans spend on average more than nine hours per day online, which is about 3 hours more than the global average of 6 hours and 37 minutes (Ruth, 2023)

Smartphone penetration globally among the youth is increasing along with advancements of technologies that could be used to aid learning and could yield a degree of positive benefits in terms of their well-being (Wong & Lim, 2023). In terms of smartphone penetration among the youth, South African students adopt a range of cloud-based platforms to the extent that mobile devices are perceived as means for gaining social status, which aligns with digital social capital theory (Adam et al., 2015).

Alongside this, the reality is that the use of mobile devices among young people has the potential to disrupt their focus and negatively affect their mental health due to the persistent need to be connected and the inclination to continuously share insights into their daily lives with their virtual social circles (Marciano et al., 2022). Despite this, the ubiquitous nature of smartphones will not diminish, and adoption will continue to increase.

Academics across higher education institutions continue to grapple with student engagement and face competition from smartphones and applications therein, both inside and outside of the classroom when trying to get students to engage with learning material. Academics have explored different active learning approaches including classroom discussions, peer learning, offering autonomy in assessments, capitalizing on social media, and integrating game-based and integration of gamification (Encarnacion et al., 2021; Karnad, 2014; Kim, 2017; Zhang et al., 2004). These approaches have yielded varying levels of success in terms of student engagement (Encarnacion et al., 2021).

South African youth utilize the multimedia features of smartphones, which is supported by the fact that Instagram and TikTok boast 5.65 million and 11.83 million users in South Africa, respectively, in 2023 (CSA, 2023). Considering that these platforms are used by the youth, the same demographic that would typically attend tertiary institutions, this paper explores harnessing the practice of students taking photographs in programming classes as a means of increasing student engagement.

This paper aims to understand programming students' utilization of photographs taken in class by answering the following questions:

1. Why do students take photographs in programming lectures as opposed to writing notes?
2. How do students utilize the photographs they take in programming lectures?
3. What perceived benefits and challenges do they experience when taking photographs in class?
4. Where do students foresee the practice of taking photographs going in the future?

This paper commences with a review of previous literature followed by an outline of the research methodology. Thereafter, the results of the study are analysed and discussed in the context of literature. Lastly, recommendations for academics are provided followed by a conclusion.

Review of literature

Studies into the influence of photographs on how students retain information is not a new phenomenon. Mandler and Ritchey (1977) explored the extent to which undergraduate students in the 1970s remembered the content of images arranged in different ways and shown to them at different intervals. Since then, several studies have been conducted on how students use photographs to learn.

Ditta et al. (2022) explored, through means of an experiment, how students retained information from photographs taken of lecture slides in class and observed that, whilst participants expected to retain information, this was not the case in some instances and that some content was forgotten. This phenomenon can be explained by an earlier study that argued that photo-taking could impair the ability to remember information, though it is not the primary factor (Soares & Storm, 2018). Delving deeper, Wong and Lim

(2023) explain that students who tend to take their own handwritten notes cognitively perform better than those who take photographs or decide not to take notes due to the fact that those who rely on using photographs or videos are affected by mind-wandering. Furthermore, whilst integrating a smartphone into classrooms present pedagogical challenges to ensure proper engagement (Anshari et al., 2017).

Despite this, there are benefits to be gained from utilizing photographs. In a study focusing on science students, Handina et al. (2020) observed that utilizing an Instagram account with learning content can facilitate increased achievement of learning outcomes. Whilst this is the case, it should also be noted that using Instagram, which is a platform that students are familiar with, could have also had an indirect positive influence on learning outcomes.

Another area where multimedia enhances learning is collaboration and engagement. Benedict and Pence (2012) investigated the use of videos posted by students in a shared online space and found that providing students with opportunities to create their own video content which can be shared with peers prompted meaningful engagement among students. Related to this, enhanced understanding of content and academic performance that was observed by Fernández et al. (2023) who explored the use of student-produced video content to learn chemistry concepts. These studies suggest that the tenets of connectivism, when integrated with multimedia, enables students to participate actively and collaboratively in the learning process (Goldie, 2016), provided guidelines are in place to avoid distractions (Anshari et al., 2017).

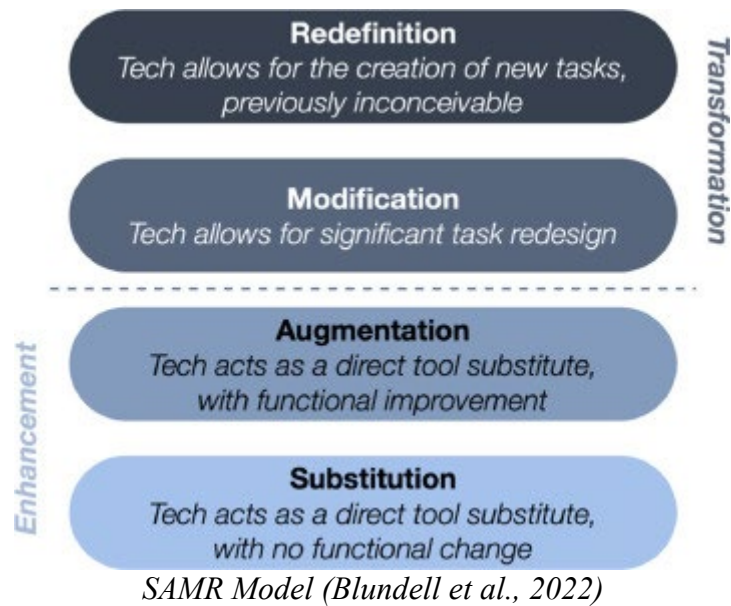
Moving closer to the field of computer science, the proliferation of video and other forms of multimedia to teach programming has been explored with varying results. To some extent, students engaged with lecturer-produced multimedia content to a greater extent than they completed practical exercises, but also found would be willing to engage more richly, given the opportunity to engage with multimedia and exercises side by side (Buffardi & Wang, 2022). Furthermore, the utilization of smartphones can enhance classroom participation allowing students to submit photographs of their classroom activities but presents challenges related to quality of the images taken and concerns around the cost of communicating with student-owned smartphones (Lindquist et al., 2007).

As can be gleaned from literature, the practice of offloading the retention process to taking photographs can yield negative cognitive and educational outcomes. On the other hand, utilizing multimedia for learning and harnessing the potential of collaborative learning could result in the process of taking photographs being beneficial for learning. Furthermore, in this study, the focus is placed on students taking photographs of their own volition and own subsequent use, a phenomenon not widely explored in literature, especially in a developing context.

Theoretical lens

After consideration of different models, the SAMR model (Blundell et al., 2022) emerged as the preferred model for this study as it is more student-focused compared to other models which focused on the media platform itself (Media Ecology) or the lecturer's ability (TPACK).

SAMR is an acronym for substitution, augmentation, modification and redefinition (Blundell et al., 2022). SAMR considers enhancement of learning by means of substitution using a technology as a direct substitute for traditional means of learning without functional change, and augmentation which is the integration of technology with some degree of functional change (Romrell et al., 2014). Additionally, SAMR also considers the transformative nature of technology for learning through modification where the learning process may be redesigned, or redefinition where new types of learning may occur (Romrell et al., 2014).



The SAMR model has been used in several studies related to mobile learning in various disciplines including science, education, language, healthcare where different features of mobile devices were explored like mobile operating systems, podcasts, video recording, text messaging, sensor data, social media and augmented reality (Handina et al., 2020; Hayhoe, 2015; Romrell et al., 2014).

In these studies, it was found that when technology provided opportunities to engage a higher level of transformation of learning, as opposed to enhancement of learning, significant benefit was derived. Furthermore, the integration of technology in terms of where is classified within SAMR is dependent on several factors including task design, availability of the technology infrastructure, students' familiarity with the technology, lecturer pedagogical knowledge, and institutional support (Handina et al., 2020).

The SAMR model is not without its flaws. These include not considering contextual factors, a rigid structure, and focusing on product over process (Hamilton et al., 2016). SAMR challenges academics to rethink how they use existing technology, and as author understands it, to shift focus towards the student as opposed to the technologies being used by the lecturer.

Despite these challenges, it is possible to use SAMR effectively provided one considers context and places focus on higher order tasks at higher levels of SAMR (Hamilton et al., 2016). Therefore, in this paper, the higher levels of SAMR are aligned with tasks that require higher levels of thinking whilst also delving into the contextual

factors associated with taking photographs in class. The way SAMR was used to align with this is discussed as results are presented.

Methodology

As previously explained, this paper aims to investigate programming students' utilization of photographs taken in class at a private South African higher education institution. Since this study aimed to deeply understand the phenomenon under investigation in a particular context without the intent of generalizing findings, it followed an interpretivist paradigm. A case study approach was adopted which gave rise to a qualitative methodology being utilised (Leedy & Ormrod, 2023).

In terms of the data collection, this study employed a focus group discussion comprising six undergraduate programming students across various years of study. After institutional permission was granted, students across different years were invited to participate in the study and students purposively sampled based on whether they took photographs in programming classes. The focus group discussion was held online after informed consent was obtained from all participants which ensured that any travel constraints did not hinder participation in this study (Sekaran & Bougie, 2016). Furthermore, audio and video were enabled for each participant allowing the researcher and participants to benefit from visual cues and allowed participants to build upon responses provided by peers (Leedy & Ormrod, 2023; Ravitch, 2020).

The 90-minute focus group discussion was recorded and transcribed. The transcription was analysed using the NVivo software package using thematic analysis which aligned to themes identified in literature. These included aspects like substitution, augmentation, modification, redefinition, social learning, enhanced academic performance, enhanced student experience, and lecturer support. Participants are afforded confidentiality and anonymity in this paper, and are referred to in the results section as P1, P2, etc.

Analysis of results

This section provides an analysis of the results of this study having followed the methodology outlined in the previous section. An analysis of the responses of the six participants of the focus group discussion are presented thematically, in alignment with the research questions. Additionally, the analysis of the results of this study are also discussed in the context of relevant literature.

Why do students take photographs in programming lectures as opposed to writing notes? This first research question was answered through the lens of substitution in SAMR where participants were asked to provide insight into reasons why they opted to take photographs as opposed to taking notes in class as well reasons for choosing to take photographs in certain courses and not others.

Participants offered insight that being able to take photographs provides opportunities for students who choose to focus on listening to the lecturer and engaging with the content in class without getting involved in the semantics of code, or trying to type everything since its stored and can be easily referred to later, *“The main reason I take photos is because whenever the lecture is explaining what they're teaching, I want to actually listen to what they're saying more than typing it down because I've noticed that while I'm sitting and typing out the code, I'm not absorbing what they're saying. So, later on when I'm*

trying to do the work or like trying to work on my code, I sometimes don't really get the concept. – P2.

Literature extends caution here by suggesting that photographs hinder the ability to maintain focus, increase dependency on the device, and reduce the quality of face-to-face interaction (Anshari et al., 2017). In this study, however, it emerged that participants use the photo-taking capabilities of their device to ensure that they focused on the classroom discussions whilst cognitively offloading as explained by Ditta et al. (2022). Given the nature of the programming discipline where memorization is not essential, the practice of cognitive offloading is acceptable, provided students refer to the images later.

In this light, one participant also highlighted being able to refer to photographs later as a reason for taking photographs in class, *“I'll take photos just to reference, and when I do reference, I go home and then go over it because it's something I need to focus on a bit more”* – P5. Thus, this result confirms that participants go back to the photographs to consult them for knowledge.

Looking deeper into this, other participants explain that taking photographs in class allows them to keep up with what is going on in class even if they need more time to better understand content: *“Whenever we move through code fast, we'll take photos. Also, when there's like a lot of notes, we don't necessarily get the lecture slides straight away.”* - P3. Another participant suggested that being able to research later was another reason for taking photographs in class: *“I would like to have like a reference too if I want to do more research on how I can see if it can be done in a different way, like if the if the application was coded in a different way to how a lecturer taught it in class”.* – P6.

Blundell et al. (2022) explored the prevalence of accessing learning materials among students and found that accessing content for later use and to further augment their learning was a prevalent practice in literature. However, they did not make a distinction here when it came to photographs taken in class.

Another factor that emerged was the convenience brought about by having immediate access to learning material on one's mobile device: *“The reason is because I don't like to sit with my laptop and study for an exam. I'd rather have it on my phone if I'm waiting in the car, I can just pull out those pictures and revise over the theory that needs to be revised over for an exam or for a test. That's coming up. So, in that way it provides a bit more convenience.”* – P4. When it comes to convenience provided by mobile devices, this is prevalent in an earlier study where podcasts on mobile devices were reported to provide convenient access to learning materials regardless of location (Romrell et al., 2014).

Another participant highlighted the fact that their perception is that if a lecturer shares something, it is the most correct of knowledge compared to notes that they take and this is beneficial to learning: *“When you take pictures, you automatically have something stored. That's definite (knowledge). There's nothing wrong with it, obviously, unless the lecturer made like an error”* – P7. None of the participants referred to the prescribed materials as authoritative sources of knowledge as they did in the case of resources shown by lecturers in class.

Ultimately, it emerges that participants take photographs in class to allow greater focus and engagement, to refer to photographs at a later stage, for convenience, and to ensure that what they are using is the most correct information that they believe is available to them.

How do students utilize the photographs they take in programming lectures?

This research question was addressed through the lens of augmentation in SAMR where participants were asked how photographs were used in the learning process to support their learning in class activities or even later when outside the classroom.

Participants provided insights that they utilized photographs both inside and outside of class. In class, photographs were a companion to assist participants with class activities: *“I use the pictures that I take during lectures would be like for example, if I'm just reinforcing. I would take a picture of something. Then I would have like my phone with me next to my laptop, and then I will see what changes the lecturer made in code and I could make the same changes” – P6.*

When it came to utilizing photographs outside of class, participants shared several use-cases including recalling content late later when working on code in their own time: *“When it comes to the practical aspect of coding, I prefer to code after 12 at night in my own space alone... YouTube isn't going to help me all the time because there's some aspects and some concepts that are taught within the lecture room that aren't available on YouTube... when you hit a challenge in your code, it's good to have a reference point to go back to.” – P4*

In line with this, the utilisation of smartphones outside of class was also observed by Anshari et al. (2017) due to the ability of mobile devices to access teaching materials or other resources using the Internet. What emerged in this study was that whilst these resources are available to students, they showed greater inclination to engage with the lecturer resources, particularly in the field of programming.

Another situation was that photographs were useful for preparation for assessments as indicated by this participant: *“In some other lectures, I'll just take pictures and keep it on my phone. Then, if I have a take home test, I'll just pull up the picture and I'll see the summary that's been written there or whatever picture that's been taken of and I'll just use that.” - P7.* This was supported by another participant who shared the following regarding the value of photographs for assessments: *“The photos are always there and on hand. So, it also makes studying and doing assignments so much quicker and it minimizes time.” – P5.*

In earlier research, it emerged that students utilised their learning material stored in different multimedia formats as being a prevalent means of transforming how they learn (Blundell et al., 2022). Furthermore, whilst not directly explored in this study, the use of smartphones to manage group assignments emerged as a factor in the study by Anshari et al. (2017) which signals a further capability of mobile devices to assist with preparing for assessments. Later in this analysis, the notion of collaboration with peers around photographs is discussed for learning rather than assessment, but the relationship between the earlier study and this study suggests that preparing for assessments is an integral part of how students use their learning resources and mobile devices.

When probed about how they access their photographs later, one participant shared they organized their content on their mobile device using folders per course for easy access (P5). However, not all participants preferred to use their mobile devices to engage content after class. Instead, there seemed to be a preference for a larger format screen among some participants who uploaded their photographs to Google Drive and accessed on a laptop (P3), transferred photographs to their laptop via USB cable (P2), or shared them to their MacBook via Airdrop (P7). Based on this, it can be argued that the practice of taking photographs on a mobile device provides convenience for students. However, the ability to then access these later across different types of devices is essential for engagement to take place.

Another aspect which a participant shared was that taking photographs allowed them to miss classes as they knew that peers would be taking photos, *“it was nice knowing that people are sending through pictures... it makes everything just less tedious.”* – P7. Whilst this does seem like a negative outcome for learning, it may be argued that being able to access resources after the fact is ultimately beneficial for those who miss class, whether intentionally or unintentionally. Such students still get to engage with material provided by the lecturer and learn at the same time. In fact, this participant confirmed that attendance did not equate to non-engagement by providing the following explanation, *“if someone’s absent or not there, everyone just sends in pictures, and you can go back and look at it to understand what’s going on.”* – P7.

This finding suggests that students form their own social circles to share photographs and multimedia taken in class with their peers. This is expanded upon in the next section.

What perceived benefits and challenges do they experience when taking photographs in class?

This research question was addressed by through the lens of modification in SAMR asking participants to share their perceived benefits and challenges with taking photographs as well as whether they felt that their learning experience was modified enhanced because of this practice. When considering earlier studies, it emerges that recall of knowledge may be enhanced by taking photographs and this could lead to greater academic performance (Ditta et al., 2022). Prior literature identifies that integrating technology yields differing levels of academic success (Encarnacion et al., 2021), and the finding of participants having a varied perceived level of academic success due to taking photographs follows through into this study.

On one end, participants felt that beyond ease and convenience, the effect on their marks was marginal, *“I think it just makes everything much easier to do, but I don't like it doesn't increase my marks rapidly”* – P7.

Towards the other end, another participant explained that the benefit allowed them to be strategic and that the time-saved due to photographs being taken allowed students to invest focus on more complex content, *“If we have the correct information from our lecture notes, it's a lot easier to refer to those than to scour Google for 10 to 20 minutes to look for something that might be on hand. So, I think it helps me perform better as I save time, so I have more time for the difficult stuff. I think it does lead to a boost in performance and grades.”* – P3.

On the other end, one participant felt that taking photos was crucial for academic success and explained that taking photos replaced the traditional means of taking notes entirely. There, it has a direct impact on their academic performance due to the shift in how they learn, *“In my case, I feel that taking notes doesn't work for me, and if that was my only option, I don't think my marks would have been to my satisfaction. So, I think that taking pictures in the lecture room does contribute to having good grades.”* – P4.

From the findings above, while taking photographs has varying perceived impact on academic performance, participants agree that it does make the learning process easier and more convenient.

In terms of perceived challenges, the first challenge was storage space for some students who take photographs and videos, *“I think definitely when you record videos, you'll delete them when you are like done with the module because they take up too much space on your phone. You don't have space to store those photos after a while, so definitely after a certain amount of time you will delete them like after the lecture, after the semesters finished.”* – P3.

The finding above was in direct tension with an earlier finding that other participant kept photographs in folders for a longer period, and challenged by another student who indicated that they kept all their photos even after modules, *“I know I don't delete my pictures. I have pictures from like work we've done last year that I know I'm not going to use going forward.”* – P7. Whilst it is possible that the storage space challenge is not confronting all students, it suggests that institutions could support with cloud storage space. In the case of the institution where the study was conducted, students are provided with cloud storage, but it would seem like this is not utilized.

The second challenge was power supply as indicated by one of the participants, *“The challenge is that the iPhone battery doesn't last the entire day, and charging is an issue ... that's the only thing that I have a problem with.”* – P4.

The third challenge was proximity to the projector screen which prompted participants to move place to get better photographs, *“It's difficult to take photos at the back of a lecture hall, and so that's you tend to move forward.”* – P3. This significance of the quality of photos taken was reiterated by another participant who also cited this as a challenge, *“I think the only issue that I've ever experienced, that I think everyone has experienced, is photo quality and people in the way.”* – P2.

The challenges associated with photo quality have precedent in literature with an analysis of major operating systems in the context of SAMR finding that the functionality of different smartphone operating systems offer different levels of user experience based on the type of media being taken (Hayhoe, 2015). Whilst participants in this study did not allude to their devices being an issue, this could still be a contributing factor if situated far from the projector or in a low-light lecture venue.

To overcome some of the challenges identified above, students have turned to collaboration with peers. A participant shared the following insights, *“It's called teamwork. We all had different angles of the same content, right? That wouldn't have been possible if we didn't share with each other.”* – P4. This was substantiated by another

participant who stated, *“Sometimes my pictures may be blurry, but my friends may look nice, so (it depends) which one (of us) has a better picture.”* – P7.

The notion of collaboration extended beyond simply overcoming photograph quality issues. Students sometimes collaborate to piece together an entire programming lecture as explained by this participant, *“Some lecturers wouldn't share their code, so everyone had a part of taking different pictures of the code. Then we all shared. So, we pieced the code up together from those pictures.”* – P7.

However, the act of sharing is not a given for all students as indicated by a participant, *“If they don't ask me to send them the specific pictures, I won't really send them the work.”* – P6.

Ultimately, it seems sharing photos unites students behind their common goal and helps them build their own sense of community: *“It's usually when someone is struggling with something and then we just say here, this is this is what it how it was done in class. You can use this.”* – P5. This is supported by another participant who indicated, *“We all want to help each other out, because we're all doing the same thing, so we want to work together.”* – P3.

Whilst simply helping each other on the same task may raise some ethical concerns around collaboration, it is known among students of the faculty that collaboration to learn as is done as is done in the IT industry, but collaboration for formal assessments is against policy.

With reference to prior literature, the utilization of student-generated video resources, albeit as part of a learning activity for other students to view, did not yield greater benefit for the overall activity (Romrell et al., 2014). It needs to be considered that when giving students activities to generate content for peers, an element on active participation and collaboration is essential.

This was evident in this study where students used their own social spaces to become contributors and creators of content. Ultimately, as defined in literature, for an activity to be redefining, it would need to offer personalization and connectedness to students (Romrell et al., 2014), which social spaces as discussed, and lecturer support, as discussed in the next section, offer to students.

Where do students foresee the practice of taking photographs going in the future?

This research question was answered through the lens of redefinition in SAMR, and participants were asked about potential inhibitors to taking photographs, their notions of consent, whether this practice could endure, and about lecturer support.

It would seem like the practice of taking photos will endure, *“I don't think that like students will ever stop taking pictures, no matter what.”* – P7. Based on this, it could be argued that lecturers need to develop and integrate into their teaching mechanisms of how to support this practice.

To aid with understanding why this would be helpful, one participant expressed the following: *“In terms of lecturers supporting, I would say it would be easier in terms of engagements because if you take a picture of a piece of code that's on the projector that,*

you can maybe go during the breaks to the lecturer and ask like that specific lecturer any follow up questions.” – P6.

In addition, having lecturer support for taking photos will result in students overcoming the rush to snap a photograph as suggested by one participant, *“more lectures could pause to allow us to take a picture before they go to the next slide or the next code snippet or class.” – P2.* This participant went on to suggest that perhaps lecturers could provide support by taking the photographs in class or upload a screenshot, *“Also picture quality and if the lecturer takes the picture, everybody is getting it. It's of uniform quality and accessible to everyone.” – P2.*

This was promptly challenged by another participant who indicated that, *“if a lecturer was to just upload like a screenshot of what they did, I would be confused. If I look back on the photo that I took, I'll know that it was exactly what I needed and what I was struggling in. It's just it's easier to know what you're looking at when you've taken it.” – P5.* This challenge was supported by another student who felt a degree of accountability and ownership from taking their own photographs. They shared, *“I feel like I've done some work in taking a picture and I know that I'm going to use it... I think that making the environment conducive for us to take our own pictures will be much more beneficial.” – P4.* From the above, it emerges that students prefer autonomy when it comes to taking and collaborating around photographs taken in class.

Ownership and accountability of the space has been discussed in literature in a study that found that affording them a sense of flexibility and ownership of which platforms to use to connect with learning materials and peers motivated them to learn (Romrell et al., 2014). This aligns with the principle of autonomy outlined by Deci and Ryan (2000). The concept of ownership for self-generated content was also observed by Benedict and Pence (2012). Furthermore, Ditta et al. (2022) argues that students retain more when they are the ones taking photographs.

However, with this accountability and autonomy must come a degree of responsibility. This was raised by a participant who indicated that having a photo or video to refer to is more useful than taking notes, provided the lecturer provides consent: *“So, having photos or even a video if you have the lectures permission to refer to and see how they've done it and how they can explain it is much more useful.” - P3*

When probed further on the topic of obtaining a lecturers' consent, students advised that consent would depend on the lecturer and provided the following reasoning: *“Different lectures have different dynamics, different personalities, and some personalities come off a bit stronger than others. Some might be more lenient than others. So, it just depends. You know, sometimes you might not even need that (consent) because they make the environment so conducive as long as you're doing whatever you're doing to benefit your studies, it's fine.” – P4.*

Another participant shared a different understanding of consent to take photographs by suggesting that consent automatically is a given if work is put up on the screen: *“I feel like since this is work that they are showing us, it's usually not an issue to take a photo of the work, but only the work. I don't normally take a video if the lecturer hasn't given permission. It's normally just photos.” – P3.*

These findings related to consent from the lecturer suggest that programming students do not have a unified view of what consent to take photographs in class entails. This provides a further opportunity for the lecturers to support and address this in their classes as this practice will likely not cease as explained by this participant, “*as long as we have phones with us, it (taking photos) will last.*” – P2.

Ultimately, Ditta et al. (2022) argue that given proliferation of technology in class, it is essential to adapt our practices to support learning using photographs taken on mobile devices.

Recommendations

Considering the analysis and discussions presented above, students are actively involved in regulating and driving their own learning, which is something academics and institutions traditionally try to facilitate using institutional platforms. However, in this study, it is observed that students use their own virtual spaces built on their own devices. The findings of this study provide an opportunity to harness devices that students already own to potentially transform and redefine higher education in the field of programming.

Romrell et al. (2014) argue that it is critical to consider aspects relating to technical or infrastructure issues, pedagogy issues, and management issues. Based on these aspects, recommendations are provided for academic and institutions.

Recommendations for academics

As can be gleaned from the participants insights, lecturer support for taking photographs in class is essential to create a conducive learning environment. It is recommended that providing support includes awareness of the intention of students who take photographs in class. Additionally, it is recommended that lecturers provide students with opportunities to easily seek consent to take photographs, videos, or audio recordings of class, whilst defining the limits and expectations related to such consent.

It is also recommended that lecturers provide students with direction on which aspects might be important to photograph or share relevant media with students to augment their learning. Lecturers may also redefine learning activities which encourage their students to harness the capabilities of their mobile devices and follow this up with a dedicated a space for students to collaboratively share their own multimedia with peers. This could take the form of a space in the institutional learning management system or an external space where students can share and interact like existing social media platforms, Microsoft Teams channels or Discord servers. This approach of giving the student control of a space aligns with connectivism (Goldie, 2016).

Ultimately, since students prefer to take their own photographs, by providing guidance, a structure, and a space for students to collaborate, lectures can harness what is already taking place informally in class and achieve the learning outcomes.

Recommendations for higher education institutions

Effective lecturer support for taking photographs in class is dependent on institutional management supporting lecturers. Therefore, it is recommended that institutions provide their students and academics with suitable on-campus Internet connectivity to facilitate the process of sharing multimedia with and between students.

Furthermore, it is recommended that when selecting institutional e-learning platforms, cognisance needs to be given to students who appreciate when they can generate and share their own content to supplement what is provided by their lecturers. Platforms need to cater to the need for collaboration and engagement among students who do create their own knowledge and engage with peers. Lastly, institutions may also factor in the findings presented in this study and other relevant studies when conducting training for academics on integrating technology into the classroom.

Based on these recommendations, the Harnessing Student-Generated Content (HSGC) Model is offered which outlines the need for institutional support at its base, is supported by SAMR at its core, but appreciates the need for student autonomy to ensure that students continue to learn in a way that serves them and are not influenced by the contribution of the lecturer:

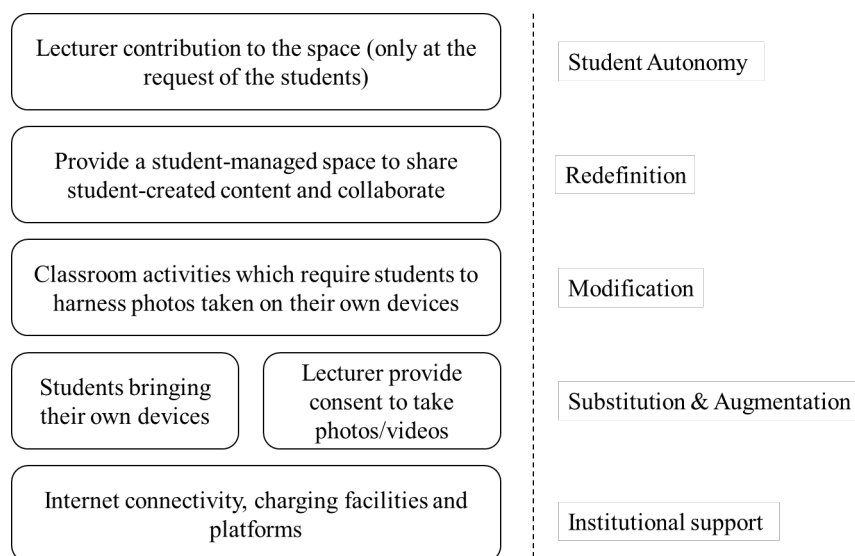


Figure 1: Harnessing Student-Generated Content (HSGC) Model

It is anticipated that this model, Figure 1, will be tested in future research along with different types of content that students may generate in class.

Conclusion

This paper sought to investigate the utilization of photographs by programming students at a private South African higher education institution. A review of literature was provided to situate this study in the body of knowledge and a theoretical lens was obtained from literature. The methodology followed was then described. Using this theoretical lens as a basis, an analysis and discussion of the findings of this study in relation to earlier works were presented. Thereafter, this paper provided recommendations for academics and higher education institutions followed by proposing the HSGC Model.

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Examining big data sources for enhanced disease surveillance in South African public healthcare

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Abstract

Disease surveillance is a vital component of effective public health management. However, the limitations of conventional disease surveillance systems have been exposed by the recent emergence of Covid-19. To address such challenges, there is a growing need to explore disruptive technologies such as big data analytics as complementary tools to traditional surveillance methods in public healthcare. In spite of this, the reliance on conventional disease surveillance methods remains substantial within the public healthcare domain. This study uses a scoping review method to investigate various sources of big data that can augment traditional disease surveillance strategies in public healthcare. The findings reveal that diverse data sources, including social media, internet of things (IoT) devices, and search data, among others, offer opportunities for real-time analysis. Leveraging big data from these sources holds promise for effectively managing disease spread and overall population health.

Keywords: big data analytics, big data sources, disease surveillance, public healthcare management

Introduction

The advent of the digital revolution has led to the unveiling of extensive datasets, commonly referred to as big data. These datasets can be generated from a variety of sources that can be associated with big data or internet of things (IOT) data such as electronic health records (EHRs), medical claims data, social media, internet search engines and crowd sources, among others. These big data sources with their real-time analysis can be used to revolutionise public healthcare which still relies on traditional systems for disease surveillance.

Public healthcare plays a vital role in society, ensuring and supporting the well-being of the general public by supplying health services to all, even the marginalised. This is seen in the United Nations Sustainable Development Goal 3 (SDG 3), which promotes that the right of every citizen to a healthy life whatever their age. This emphasises the goal set by the World Health Organization (WHO) to attain universal health coverage by the year 2030. Disease surveillance is a component of public health; it is used as an epidemiological tool to systematically monitor illnesses and their spread whilst ensuring overall population health (Aiello et al., 2020).

However, Salathé (2016) and Mremi et al. (2021) indicate that the existing disease surveillance systems in public healthcare face challenges that necessitate augmentation through the integration of state-of-the-art technologies. Traditional surveillance systems rely on information provided by healthcare professionals, forming an active surveillance system where consistent and standardised reporting is established (Barros et al., 2020). Nonetheless, maintaining this structure incurs substantial expenses and introduces considerable time lags between data collection and initial diagnosis, consequently impeding the swift or instant recognition of outbreaks. These state-of-the-art technologies

are known as disruptive technologies; disruptive technologies are technologies that challenge and supersede traditional industries, approaches, products and services (Majumdar et al., 2018). Examples of disruptive technologies include big data, digitalisation, the internet, artificial intelligence, robotics, 3D printing and renewable energy to mention but a few. The real-time analysis of big data will address the pressing need for timely analysis within the context of disease surveillance processes in public healthcare (Mwamnyange et al., 2021). Furthermore, the application of big data in public healthcare can assist in providing initial medical assistance to patients (Panda et al., 2017). For instance, big data algorithms can be trained to evaluate the gravity of the circumstances and recommend appropriate immediate medical care or direct emergency cases to the relevant medical specialists. Alonso et al. (2017) allude to the fact that in the healthcare domain, the analysis of big data could open up novel opportunities for creating predictive models, identifying behavioural patterns, uncovering emerging requirements, mitigating risks and delivering highly personalised services.

In disease surveillance, the technology of big data through its sources can be used to monitor and track the spread of diseases in real time. This allows for early detection and response on the part of public healthcare authorities (Zheng, 2021). Big data refers to datasets that have the three primary characteristics of high volume, variety and velocity. This data then requires processing using specialised techniques or methods (Kapil et al., 2016). Furthermore, the attributes have extended beyond the core "Vs". Additional "Vs" have been introduced to broaden the scope of the big data definition, tailored to the unique perspectives and needs of organisations and individuals (Khan et al., 2019). For example, Tsai et al. (2015) added the characteristic of value, Khan et al. (2019) added viability and Hariri et al. (2019) added veracity. The use of big data alone will not yield advantages for the healthcare field; rather, it must undergo processing to extract meaningful insights from the extensive datasets at hand. This is referred to as big data analytics (Chatapura & Ramafi, 2022).

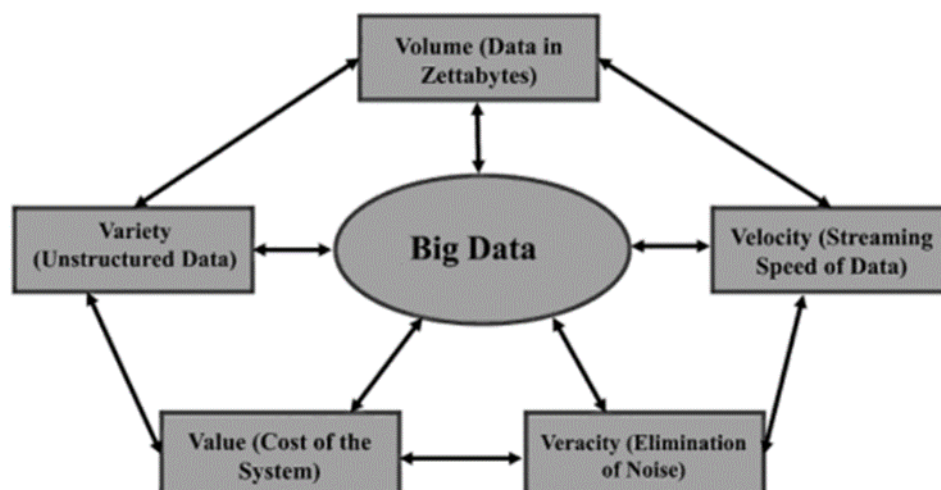


Figure 1: Big data
Source: Adapted from Rani et al. (2023)

Big data analytics requires specialised tools and techniques to able to obtain wisdom from the collected big data (Tsai et al., 2015). According to Sahu et al. (2021), the combination of data from big data analytics sources and IoT devices can be harnessed for

disease surveillance within the domain of public healthcare. These big data sources include data from social media (Bansal et al., 2016), internet searches (Amirian et al., 2017), crowd sources (Tsou, 2015), wearables (Garattini et al., 2019), ambient sensors (Sahu et al., 2021) and EHRs (Lin et al., 2018).

Problem statement and objectives

The objective of this research was to understand various big data digital technologies that can be used to augment traditional disease surveillance systems within public healthcare in South Africa. To achieve this, we conducted a scoping review study. The study also looked into the challenges and benefits associated with various big data sources that could be used to augment disease surveillance systems. Effectively incorporating these sources of big data in order to enhance disease surveillance can empower authorities to achieve the real-time monitoring and tracking of diseases. This capability, in turn, enables the prompt implementation of controls, leading to enhanced population and environmental safety on a broader scale. In South Africa, a low medical expert-to-patient ratio leads to elevated medical costs, which heightens patients’ challenges, particularly those residing in rural areas, when attempting to access adequate healthcare in their vicinity. This is despite the fact that the South African healthcare sector has committed to ensuring that healthcare services are made accessible to every citizen regardless of their age and ability to afford it. For that reason, to be able to enhance the current traditional disease surveillance systems in public healthcare, meeting this objective requires prompt systems that are timely and cost-effective. The majority of these digitally sourced big data streams are cost-effective and have more rapid response time compared to the traditional disease surveillance systems currently utilised in public healthcare. As a result, this study investigated various big data digital sources that could be used to augment current disease surveillance systems.

Literature review

Digital health surveillance (DHS)

DHS refers to the use of data-driven digital technologies to monitor and analyse healthcare-related affairs using real-time analysis and reporting (Donelle et al., 2021). According to Kostkova et al. (2021), DHS, unlike traditional disease surveillance, is timely and also integrates a variety of big data sources. In this section, a number of digital sources of big data are examined.

Terms for digital health surveillance

Table 1: Terminologies used to describe digital health surveillance

Terminology	Author
Syndromic surveillance systems	(Ferraro et al., 2021)
<u>eSurveillance</u>	<u>(Stroetmann et al., 2017)</u>
Digital epidemiology	<u>(Salathé, 2016)</u>
<u>Infodemiology</u>	<u>(Mavragani, 2020)</u>

Big data sources used to enhance traditional disease surveillance
Internet of things (IoT)

The advent of the IoT has been beneficial for extracting information for disease surveillance in healthcare in the 21st century (Mathew et al., 2015). The IoT refers to technological innovation in which devices and people can connect with each other in real time through an internet connection (Sahu et al., 2021). In healthcare, the IoT can also be used to for disease surveillance (Gilbert et al., 2019) and environmental wellness and monitoring (Yang et al., 2019). Devices used to connect to the IoT employ existing technologies to help gather and store meaningful data. For instance, sensors, big data analytics and cloud computing can help with data generation and storage before automatically transferring data to other IoT devices (Rani et al., 2023). Furthermore, IoT devices have unique addresses that make it easier for them to be tracked over the internet. The primary objective of IoTs is to facilitate global connectivity for individuals at any location and time through the internet. The IoT can connect sensors, mobile devices, mobile applications, radio-frequency identification (RFID) tags and wearable devices with accelerated data collection (Asghari et al., 2019). As a result, the IoT has expedited communication by facilitating interactions between humans and machines, as well as machine-to-machine communication. This offers a diverse array of communication options and diminishes the time lag associated with communication (Sahu et al., 2021). Consequently, leveraging IoTs for disease surveillance becomes crucial, particularly considering the urgent nature of disease surveillance in public healthcare and the real-time analysis of IOTs. Despite the advantages of the IoT, there are also challenges associated with employing it, such as healthcare authorities' incapacity to combine data from various community sources (Sahu et al., 2021).

Online searches

Online searches refer to the use of search engines like Google and Yahoo to find information on the internet (Bernardo et al., 2013). Search engines use disease associated keywords which are then used by people to understand certain diseases in depth so as to monitor who, what and where the search is occurring from using real-time insights (Huang et al., 2016). Consequently, they assist public health authorities in their surveillance and response efforts to combat diseases and their spread. For instance, Google Flu Trends (GFT) was used to surveil seasonal influenza outbreaks (Olson et al., 2013). Brammer et al. (2011) suggest that conventional disease surveillance systems typically lag behind digital ones when it comes to reporting time, hence the need for faster systems. Google Flu Trends was eventually discontinued after it failed to accurately identify and forecast the 2009 A/H1N1 pandemic (Aiello et al., 2020). This has caused Google to rely solely on aggregated search volume data accessible through tools like Google Trends, employing time series analysis of relative volumes for particular search terms, and Google Correlate, which involves examining correlations and comparative trends across different states (Mavragani et al., 2018).

Crowdsourcing

Crowdsourcing is a technique used in disease surveillance to gather healthcare data. It makes use of a collaborative effort by substantial online communities to construct a dataset (Lee et al., 2021). Tong et al. (2020) state that crowdsourcing entails recruiting participants online and in the conventional media to engage in recurring web-based surveys. These surveys encompass comprehensive symptom reporting and the submission of disease distribution observations through online maps and newsletters. According to Lee et al. (2016), crowdsourcing has the ability to link geography to specific health behaviours, which is important because it provides context to the spreading of diseases. Furthermore, according to Saran et al. (2020), spatial crowdsourcing allows for

spatiotemporal modelling which helps analyse and predict trends, patterns and relationships for variables over time and space. As a result, public healthcare officials are able to identify and understand disease patterns and trends and their relationship with overall environmental elements (Khedo et al., 2020). Spatiotemporal modelling enables the healthcare community to not only detect the presence of a specific disease but also to track its evolution across different time intervals, sequences and rates of change. According to Rice (2019), an example of crowdsourcing is the use of the HealthMap application, which allows users to add disease outbreaks and health-related events through its “Add an alert to the map” feature. This application is then used by officials to report on disease-related news in real time. However, despite the benefits mentioned the use of crowdsourcing is still facing challenges. For instance, Tong et al. (2020) highlight that privacy control and quality control are still major challenges when it comes to using crowdsourcing mechanisms to generate insights from the public. Lee et al. (2016), on the other hand, identified biased and incomplete data as a challenge, since not all individuals may be technology savvy which is a primary requirement for crowdsourcing.

Social media

The term ‘social media’ refers to digital platforms that enable public users to produce, share and interact with content, ideas and information in a virtual social setting (Kaplan & Mazurek, 2018). As an example, Eghtesadi and Florea (2020) mention Tik Tok, Lee et al. (2013) mention Twitter and Gittelman et al. (2015) mention Facebook as social media platforms that have been used, and are capable of, serving as channels for disease surveillance. Increasingly, these social platforms enable the exchange of information among individuals and communities through diverse mediums such as text, images, videos and hyperlinks. According to Aiello et al. (2020), the identification of content occurs via keyword searches and updates through natural language processing, aimed at recognising content associated with health conditions like influenza. The attractiveness of social media is found in its ability to gain access to user generated data that is able to assist public healthcare to identify and control disease in real time. However, although social media platforms can be used as a means of disease surveillance sources, they are not without challenges. For instance, Lui et al. (2021) highlighted misinformation on diseases as one of the challenges experienced when using social platforms for disease tracking.

Electronic health records (EHRs)

An EHR is a softcopy version of a patient’s healthcare information, for example their medical history, treatments, diagnoses and medical results (Evans, 2016). Moreover, Birkhead et al. (2015) refer to an EHR as an electronic record-keeping system that provides long-term patient information that is interoperable and accessible between numerous healthcare divisions. Additionally, according to De Bie et al. (2015), the development of EHRs has shifted current disease surveillance systems from the use of traditional data to now incorporating EHRs as a source of healthcare data. An example of this was witnessed during Covid-19, where EHRs were used to monitor the spread of the disease and also analyse the impact of the interventions being put in place by healthcare officials (Satterfield et al., 2021). In healthcare, EHRs characteristically bring advantages especially where clinical care is concerned; however, they also have the ability to benefit more areas within public healthcare. Consequently, they are also beneficial in disease surveillance by providing centralised and all-encompassing patient information (Chan et al., 2022; Figgatt et al., 2021), as well as improving patient care coordination and communication between stakeholders. Furthermore, Gianfrancesco et al. (2018) mention

that EHRs can help identify trends and patterns in healthcare outcomes in order to enable informed decision-making within the healthcare space. However, the benefits are not without challenges, for example the limited interoperability and standardisation of data housed in EHR systems (Vogel et al., 2014). Piasecki et al. (2021) also highlighted that the use of EHRs comes with many ethical concerns.

Wearable devices

Bradshaw et al. (2019) define wearable devices as objects equipped with sensors that can be attached to or worn on the body. These technological devices use sensors to collect and track information about the individual's activities and behaviour in real time (Cosoli et al., 2021). At the heart of wearable technology is lifestyle monitoring, which is accomplished by using fitness trackers, smart watches, or even smart clothes, ultimately empowering users to take control of their own health by being the primary monitors of their own health data (Bradshaw et al., 2019). Gielen et al. (2021) state that wearable devices are successful because they are known to be non-invasive and contactless in their data collection. Health wearables are used to monitor health vitals such as temperature, heart rate and blood pressure (Seshadri et al., 2020). Furthermore, steps taken over time, sleep duration and the locations an individual has been in can be reported (Gambhir et al., 2021). For instance, during the Covid-19 epidemic in the United States, a Biostrap device to track changes in vital signs was used to determine whether individuals were exhibiting symptoms. This is another example of a wearable technology being used in disease monitoring (Gielen et al., 2021). Another example is the Parkinson's disease sensor system, which is a wrist-mounted accelerometer used to generate data, monitor heart rate and sound an alert if there is a need, based on the conditions set out (Huang et al., 2016). Despite the advantages of adopting wearable technology in disease surveillance, a lack of knowledge about the technology remains a significant obstacle to its incorporation (Gielen et al., 2021). As Cosoli et al. (2021) mention, measurement accuracy is still an issue when it comes to using wearable technology for disease surveillance purposes.

Theoretical framework

The theory used for this study is the social construction of technology (SCOT). SCOT highlights the influence of social variables on the way in which technical artifacts are developed, adopted and used (Oti-Sarpong & Leiringer, 2021). The theory offers an approach for analysing the environment in which different technologies are used (Sakamoto & Yamada, 2020). Accordingly, regulators are motivated by the SCOT lens to consider how new technologies incorporate social values and reflect the culture and overall social wellbeing of participants. For this study the theory helped to address challenges raised when integrating digital disease surveillance, and how digital big data surveillance could be considered to enhance traditional disease surveillance in order to protect overall population health.

Methodology

Research design

This section provides an overview of the methodology used in this study. The methodology chosen was influenced by numerous variables, including the purpose of the study, the goals of the study and the data required to address the research questions. An interpretivist research paradigm was used to guide this study. This paradigm is associated with qualitative research, which aims at understanding human behaviour and interaction in social settings (Pulla & Carter, 2018). Interpretivism was deemed appropriate for this research study as it sought to understand digital disease surveillance, different big data

analytics sources and what they mean to people coexisting in the public healthcare space. The following section discusses the way in which sampling was carried out for this research. It also discusses the eligibility criteria, information sources and the search string development. Further, sections 4.2.2 and 4.2.3 outline the three-step search strategy applied and section 4.2.4 offers data mapping and analysis.

Sampling method

Sampling in research is the process of choosing a portion of people from a broader population or group in order to examine or analyse them to understand a phenomenon better (Etikan & Bala, 2017). For this study purposive sampling was used to select the sample used. This is because the study involved a scoping review, where both the study sample and the studies used were intentionally selected. Additionally, the eligibility criteria served as a guide for creating the search string that was utilised to locate relevant publications, outlining what should be included and excluded within the research. After being obtained, the papers were further examined for relevancy based on the title, abstract, index keywords and references. Only English articles were considered since this made it easy for the researchers to acquire and understand the information in the papers. To ensure that debates were based on the most recent results and to avoid the occurrence of outdated data, we strived to obtain data for the review that was published within the last five years. We also preferred the use of published content since this had already been through peer review and had been verified as accurate, allowing it to be utilised again in future studies.

Eligibility criteria

- Language: English
- Years considered: 2018–2023
- Publication status: published

Information sources

The study used five databases: PubMed, Scopus, Web of science, Scholar and Emerald Insights.

Search

The search was carried out using the advanced search features of the databases indicated and the search string was created using the following criteria:

- Concepts: essential concepts studied in this research are “big data analytics” and “big data sources”, therefore these phrases were both included in the initial search string.
- Context: “disease surveillance” was the context that was investigated; as such, this phrase formed part of the initial search string.
- Population: the focus of this research was on public healthcare; however, a specific word to take the population into consideration was left out in some of the search queries.

Table 2: Development of search string

	No.	Concepts	Context	Population
Initial keyword development	1	“Big data analytics”, “big data sources”	“Disease surveillance”	“Public healthcare”
	2	“Big data”, “data sources”	“Disease control”	“Public health”
	3	“Data analytics”, “multi sources”	“Epidemiology”	“Healthcare”
Inclusion criteria	Final keywords	Big data analytics, disease surveillance, public healthcare		
	Final search string	“Big data analytics” AND “Public healthcare” AND “Big data sources” AND “Disease surveillance” AND “Public healthcare” OR "Healthcare "		

Data mapping and analysis

In this part of the study, the extant literature on the subject of big data analytics and employing big data sources for disease monitoring in public healthcare was systematically and graphically mapped. In contrast, an analysis was carried out by selecting, condensing and combining pertinent data to address the study research goals.

Data items: the variables considered are listed below:

- Author(s)
- Year of publication
- Source origin/country of origin
- Aims/purpose
- Study population and sample size
- Key findings that relate to the review question
- Information systems (IS) theory
- Recommendations for future studies

Data collection

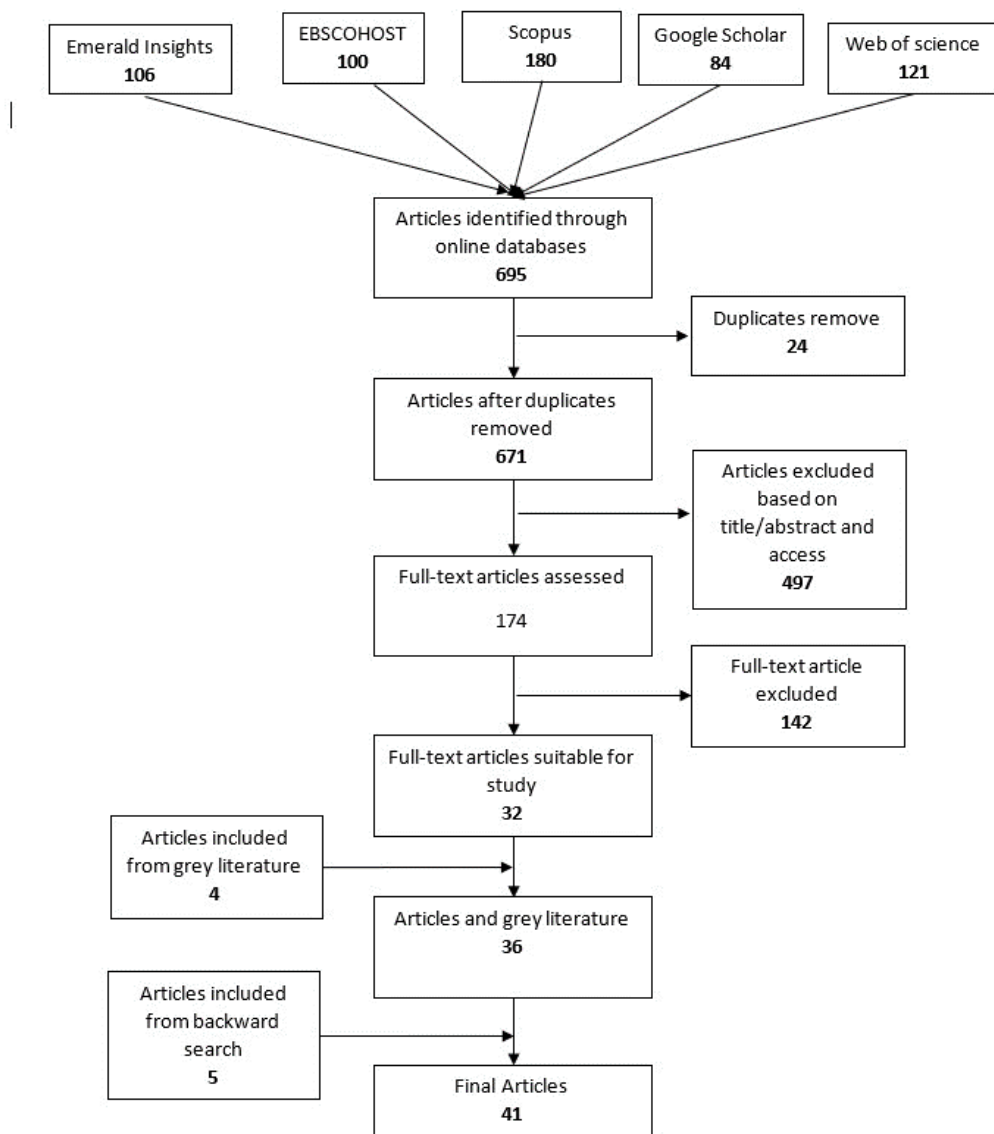


Figure 2: Prisma diagram

Data analysis

In qualitative research, data analysis comprises an iterative procedure which involves intense engagement with the generated data to uncover insights and meanings from which to develop themes (Ravindran, 2019). Accordingly, themes that arose from the collected data were identified, examined and reported on using thematic analysis. Thematic analysis is used to find and examine patterns (themes) in textual, visual or auditory data (Braun et al., 2022). This study followed the six stages of thematic analysis proposed by Clarke et al. (2015):

1. Familiarisation with data
2. Generating initial codes
3. Searching for themes
4. Reviewing themes
5. Defining and naming themes
6. Writing the report



Figure 3: Keywords from code analysis

Results and findings

From the evidence gleaned from the literature it is clear that big data analytics sources are essential for augmenting traditional disease surveillance. According to Wolfe et al. (2021), infectious disease outbreaks and epidemics are most common in Africa, and are frequently exacerbated by inadequate health systems and infrastructure, late detection and ineffective outbreak response. The WHO has developed a disease surveillance strategy called the Integrated Disease Surveillance and Response (IDSR) with the aim of improving disease surveillance in Africa. The IDSR enables the transfer of surveillance data from low levels (community and facility), where the data is created, to the district and national levels and subsequently to the WHO (Mremi et al., 2021). Nevertheless, Liu et al. (2019) state that this strategy lacks the integration of advanced surveillance methods which will improve decision-making based on insights and trends from the collected data. As a result, this strengthens the need for Africa to have enhancement strategies for disease

surveillance processes. Furthermore, Choi et al. (2016) highlighted that big data sources are instinctive, adaptable and inexpensive and can be used for monitoring diseases and also for operating in real time. However, challenges exist in the incorporation of this digital surveillance technology in public healthcare. For instance, three themes were identified in the literature: technology (Salathé, 2016), ethics and governance (Mello & Wang, 2020) and resources (Mwamnyange et al., 2021).

Table 3: Challenges with integrating big data sources into healthcare operations

Categories	Groupings	Authors
Technical	Interoperability	Sahu et al. (2021), Van Sinderen and Costa (2016), Amirian et al. (2017)
	Data quality	Sahu et al. (2021), Mwamnyange et al. (2021), Mremi et al. (2021)
	Security	Gilbert et al. (2019)
	Noise from data	Asamoah et al. (2015), Bansal et al. (2016), Chan (2019)
	Suitable strategies for data gathering, storage and analysis	Bui et al. (2021)
	Privacy	Bui et al. (2021), Abouelmehdi et al. (2017)
	Lack of transparency in how search volumes are attained	(Barros et al. (2020), Degeling et al. (2020), Ienca and Vayena (2020)
Ethics and governance	Privacy	Bui et al. (2021), Garattini et al. (2019)
	Data ownership	Raghupathi and Raghupathi (2014), Mehta and Pandit (2018)
	Consent	Gilbert et al. (2019), Garattini et al. (2019)
Resources	Funding	Yves (2020)
	Skillset	Mgudlwa (2018)

It is obvious from the aforementioned observations that the integration of big data analytics sources has its limitations, hence provoking doubt. However, this does not imply that they are ineffective. At this stage, big data analytics sources may be utilised in developing nations like South Africa to supplement current surveillance systems and also as alerting systems to discover, anticipate and research illness patterns. Additionally, disease surveillance based on digital surveillance systems such as big data sources can simply be applied to surveil various diseases, as the underlying mechanisms are similar (Choi et al., 2016). When using big data analytics sources for disease surveillance, technological, ethical and governance, and resource limitations in public healthcare, which must first be taken care of. The completeness, interoperability, timeliness and consistency of the data are just a few examples of the factors that define data quality, which is an umbrella term for a collection of dimensions that characterise certain data features to establish their quality (Altendeitering & Guggenberger, 2021). For instance, to address data quality challenges there is a need for standard accepted cleansing techniques in healthcare to regulate data formats, remove inconsistencies and further validate the generated data. According to Abedjan et al. (2016), this could be achieved by using various techniques to detect data errors such as using outliers, duplicates, pattern violations, rule violations and semantic dashboards. Moreover, the use of healthcare

interoperability standards like HL7 FHIR to provide seamless communication across various systems is the answer to interoperability difficulties (Angula & Dlodlo).

According to Jia et al. (2020), big data is a two-edged sword; while it has many benefits, it also raises concerns relating to security and privacy issues which are becoming more widespread among the general population. Therefore, in terms of security, privacy and ethical challenges, strong access control mechanisms have to be put in place. Increasingly, the use of data protection acts and regulations has to be considered, for example the Health Insurance Portability and Accountability Act (HIPAA), the General Data Protection Regulation (GDPR) and the Protection of Personal Information (POPI) Act. For all of the aforementioned suggestions to be realised, policymakers and regulators should engage with healthcare professionals to create a new legal framework that protects privacy and security while maximising the benefits of big data. This will help South African public healthcare reach the goals set by the IDSR.

A certain level of security must be attained in order to exploit big data sources ethically. Personal information and health-relevant data are necessary to record in order to provide regular health service. However, user's privacy and security are intimately associated to personal information and data that is pertinent to health (Xiang & Cai, 2021). Furthermore, this is due to the high level of sensitivity of healthcare data (Abouelmehdi et al., 2018). Moreover with this still being the case; in South Africa privacy is still a right according to the constitution (Khamroi & Shrivastava, 2019). Hence, De Villebois Castelyn et al. (2020) alludes that protecting personal information is essential to the freedoms that provide an inclusive and democratic society. According to Ferdousi (2020) there are three qualities are used to establish data security, the confidentiality, integrity, and availability (CIA). Furthermore, organizations (data collectors) should adhere to data security standards in order to safeguard their data from unauthorized access, use, disclosure, interruption, alteration, or destruction (Conrad, 2022). HIPAA, the General Data Protection Regulation, and POPIA are a few of the laws that govern how data is used, generated, and shared globally in healthcare (Olorunju, 2019). Furthermore, the ISO/IEC 29100 standard is relevant because it is an international standard that provides a high-level framework for the protection of personally identifiable information (PII) within information and communication technology (ICT) systems.

According to this standard, the three security key principles of security are broken are simplified into other simplified sub-element. For instance; consent and choice, purpose legitimacy and specification, collection limitation, data minimization, use, retention and disclosure limitation, accuracy and quality, openness, transparency and notice, individual participation and access, accountability, information security, privacy compliance (Drozd, 2016). Katurura and Cilliers (2016) also assessed the POPI Act, which emphasized the fact that it touches on the security sub-elements in an abstract way. For example, the study discovered that while the POPI Act regulates the majority of privacy principles, it makes no mention of a specific privacy management program or anonymity of presence. According to Brand et al. (2022) the COVID-19 pandemic has brought attention to the need for an accessible and trustworthy data ecosystem that might help control public health hazards especially in South Africa. The study further alludes that the African continent has various health data acts which are not uniform in terms of their data sharing principle. Some of the African countries such as South Africa and Kenya for instance are stringent with their data sharing understanding which require an information regulator or equivalent party to authorise the exchange of information. Unlike Nigeria

and Uganda which have more moderate data sharing acts which does not require a regulator mediation. This is an issue by itself since timely data sharing among nations is essential to the prevention and management of illnesses and to the ability of the public healthcare system to make informed decisions. In contrast to the EU, where the General Data Protection Regulation (GDPR) provides a uniform legal framework for all EU Member States, sub-Saharan Africa has a diverse legal landscape governing data sharing, including stringent data export provisions, which highlights the need for cross-border data transfers to be evaluated on a case-by-case basis.

Conceptual framework: big data analytics sources for disease surveillance (BDSDS)

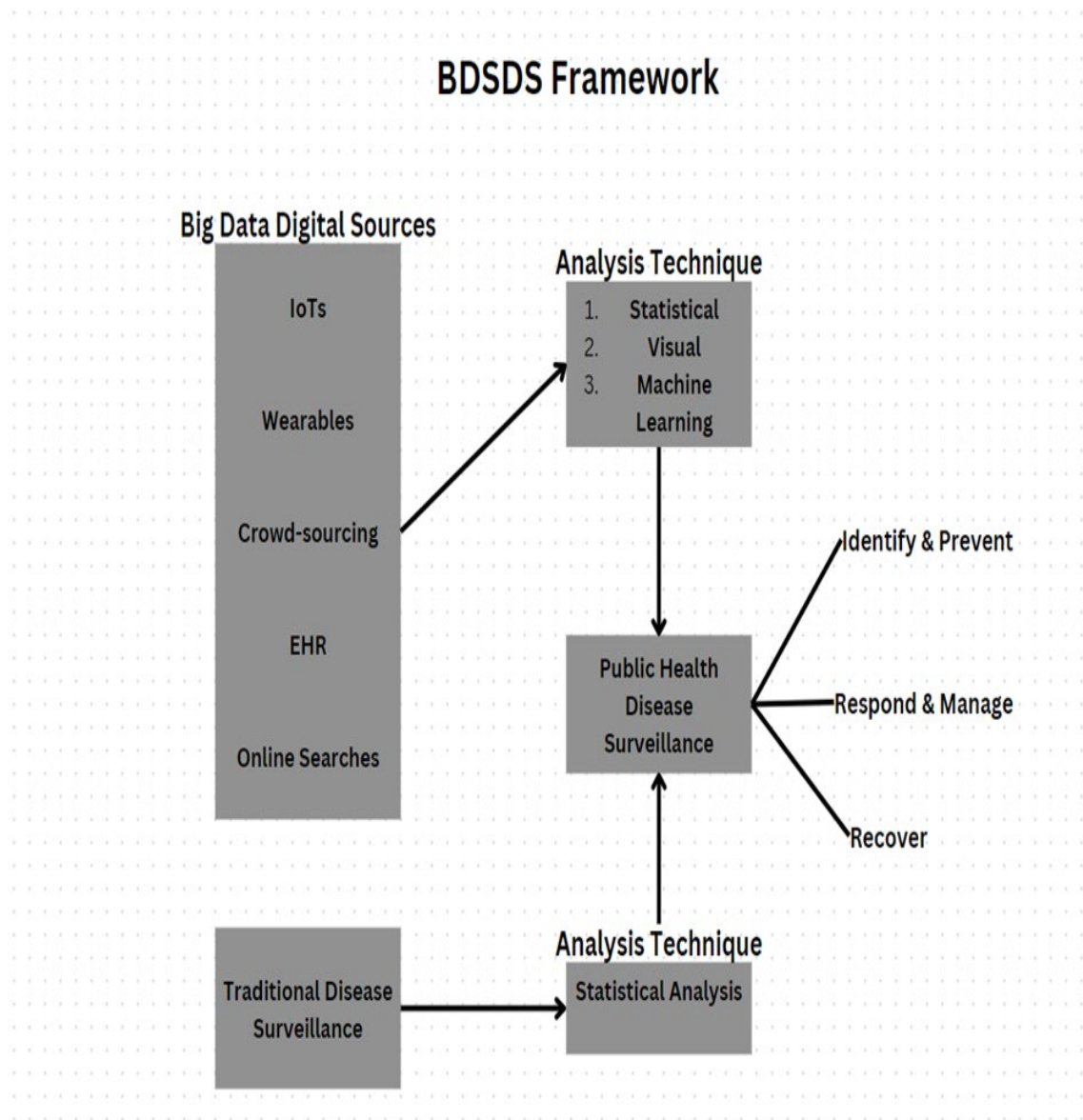


Figure 4: Big data analytics sources for disease surveillance (BDSDS)

Big data analytics sources are effective in the discipline of disease surveillance. Furthermore, these resources are affordable and accessible to practically all South Africans who are economically engaged, particularly in light of Mgudlwa’s (2018) finding that a significant percentage of the country’s population has smart devices. The first step to being able to take part in digital surveillance using big data sources is to have

a smart device that can access social media, IOT and EHRs, which are some examples of big data sources. These sources have the advantage of real-time analytics, which differentiates them from traditional disease monitoring systems. This implies that they may apply a variety of digital analytics approaches, including visual analytics, machine learning and statistical analytics, which are now employed by conventional disease monitoring. As a result, this study suggests big data analytics sources should be integrated into public healthcare and used as enhancing mechanisms to overcome the limitations of the current traditional surveillance systems in use in this sector. This will assist public healthcare in achieving its disease monitoring goals, which include identifying, preventing, reacting to and managing disease, as well as recovering from epidemics.

Conclusion

In conclusion, incorporating big data analytics sources into established traditional disease surveillance techniques has enormous potential to improve the efficiency of public healthcare. It is now possible to have a more thorough and up-to-date understanding of disease trends, patterns and prospective outbreaks because of the use of cutting-edge digital technology and the enormous volumes of data that are being produced in the current digital era. Public health authorities may discover health hazards early, allocate resources more effectively, and adopt prompt treatments to lessen the impact of illnesses by combining traditional monitoring techniques with big data analytics. By combining conventional and digital methods, healthcare systems are given a potent toolkit for preserving public health and ensuring the overall wellbeing of communities. The ongoing investigation and improvement of this integration will surely be crucial in determining how disease surveillance and medical procedures are carried out in the future.

Future Studies

Future studies can investigate ethical considerations when it comes to the use of big data analytics sources in enhancing traditional disease surveillance systems. Furthermore, future studies could consider preparedness criteria for public healthcare facilities in their quest for the integration of new digital technologies to augment disease surveillance.

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Investigating the influence of big data analytics on the campaign outcomes of political parties, South Africa: A scoping review

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Abstract

The purpose of this study is to investigate the influence that Big Data Analytics (BDA) can bring to bear on the campaigns of political parties in Africa, especially in South Africa. This research study intends to develop a BDA adoption framework that can be used by South African political parties in implementing BDA in their campaigns. A qualitative research approach is used by conducting desktop research to gather past scholarly work on the usage of BDA in political campaign strategies. Furthermore, the scoping review approach was then used to conduct a thorough analysis of the data acquired for this study. It is discovered that BDA has a lot of benefits, the most common benefit that political parties experience is gaining or extracting valuable information from the data that has been collected, this data is then used to guide the decisions of the political parties for political campaigns. Furthermore, Political parties are also able to use the insights gathered from Big Data to persuade voters to vote. It was further discovered that the biggest challenge that may hinder the adoption of innovations or may play a role in reducing the rate of adoption of BDA in political campaign strategies is the legal system, this includes all the Data protection laws and regulations along with the consequences associated with breaking these laws.

Keywords: *data-driven campaigns; microtargeting; political campaigns; political parties; Big Data Analytics.*

Introduction

Like any other industry today, the business industry is highly dependent on data, which has given rise to the concept of data-driven decision-making. The term Data-driven decision-making is described as the use of facts and data including measurements to influence strategic business decisions that correspond with projects, objectives, and goals; This is the concept of big data, which is widely accepted, gaining rising interest in different fields and endeavors (Agrawal et al, 2011) (Bousdekis et al, 2021). The present degree to which data can be generated and made available is one of the main reasons for the existence of the Big Data phenomenon; Big Data is defined as a large volume of data that necessitates the development of new technologies and architectures to extract value from it through the collection and analysis process (Mills, 2019). Furthermore, According to Mills (2019), Big Data is considered to be diverse, complex, and large in scale and as a result, analytics is required. Big Data Analytics can be defined as the process of discovering trends, linkages, and patterns that exist in large datasets that typically cannot be identified by data management approaches and Technologies.

Big Data Analytics is significant in the drive of political campaigns, this does not apply only to developed countries but rather across the globe. According to Kreiss (2016), modern campaigning has entered a new technologically demanding period and data-driven campaigning is quickly becoming a normal component of political campaigns throughout the world. In the field of political campaigns, Big Data Analytics is considered to be useful not only for analysing voter behaviour as a business prospect but also for analysing voter behaviour as a campaign target during political campaigns via people's internet usage behaviour (Irwansyah et al., 2020). Political campaigns are the mechanisms used by political parties or candidates to prepare and communicate to voters their ideas and stances on topics in the run-up to Election Day. The main purpose of political campaigns is to increase the likelihood of winning; therefore, every aspect of a campaign is analysed based on how many votes an action would create and at what expense; This is a cost-benefit analysis that is performed through accurate forecasts of voters' preferences, their predicted behaviours, and reactions to campaign outreach (Irwansyah et al, 2020) (Sudhahar et al, 2015). Furthermore, Dommett (2019) noted that there is substantial evidence that some political campaigners agree that data is important for election success; this notion has had significant implications for the way political campaigns are carried out. Currently, modern campaigns are able to evolve informed electoral strategies and guide tactical operations through the creation of databases that contain detailed information about citizens (Anstead, 2017).

Big Data is used across several industries and these industries make use of Big Data and its analytics to gain insights that improve their decision-making processes and give trust in critical situations after having analysed the data. Today, Modern political campaigns are making use of Big Data Analytics, however, it is still underused in developing countries. Therefore, this research study aims to investigate the influence that Big Data Analytics (BDA) can bring to bear on the campaigns of political parties in Africa, especially in South Africa. It reviews the extant literature on BDA, and its application to political campaigns in other regions to facilitate the analysis of how these can be leveraged by political parties in South Africa. Therefore, the research question of this paper is: How can the use of BDA influence the outcome of political campaigns of political parties in South Africa? Furthermore, an IT adoption framework is developed that can be used by South African political parties in implementing BDA in their campaigns.

Literature review

Data sources used in political campaigns

Data is the foundation of modern political campaigns. According to (Kreiss and Howard, 2010), citizens generally support the usage of data in connection with the electoral process. Many supporters willingly provide information to political campaigns, but these campaigns also purposefully gather information about their fellow citizens through canvassing in order to help the election of the candidates they are in support of (Kreiss and Howard, 2010). According to the International Institute for Democracy and Electoral Assistance (International IDEA, 2018), parties are increasingly using Big Data on voters, this data is aggregated into datasets that enable them to gain a highly detailed understanding of the behaviour, opinions, and feelings of voters which allows parties to cluster voters into complex groups. As a result, it often seems like campaigns make use of sizable informational databases that are made up of information from many (and perhaps dubious) sources (Dommett, 2019). In addition, Dommett (2019), has categorized data sources into 4 categories, this is shown in the image below.

	Disclosed data		
Data made available without charge	Free data disclosed by individuals <i>Electoral roll; marked register; canvassing insights</i>	Purchased data disclosed by individuals <i>Social media data; commercial data</i>	Data that is purchased
	Free inferred data <i>Canvassing inferences; email lists</i>	Purchased inferred data <i>Look-a-like audience matching; data modelling</i>	
	Inferred data		

Figure 1: sources of data

Benefits of big data analytics

Data matching and profiling

Data is crucial in political campaigns, especially when it has been aggregated because it may reveal a lot about a person, including their political beliefs (Karunian et al., 2019). Cross-matching and profiling enable campaigns to compile information from various sources and with the aid of sophisticated data analysis, produce assessments of individual or group preferences, interests, and behaviour that may be potentially incredibly accurate (Cavaliere et al., 2021). In general, data profiling is done for a variety of reasons. For example, inferring or predicting information, scoring, ranking, evaluating, and assessing individuals, making, or informing a judgment about an individual, as well as a decision that personalizes the environment of an individual (Karunian et al., 2019). The 2016 trump campaign is an example of how data matching and profiling can be used in elections. Dr Kogan built a software known as “thisisyourdigitallife” which was initially used to collect data for academic reasons, this data was later passed on to the political and military strategy firm known as Cambridge Analytica which was hired by the Trump campaign. Facebook users were asked to complete the app's personality tests and those who completed these tests were compensated and agreed to have their data (and the data of their friends) gathered by Dr Kogan. Cambridge Analytica after having developed a relationship with Dr Kogan used the 87 million Facebook data points collected from the app to construct personality profiles for voters and target them with carefully customized material (ICO., 2018).

The value of BDA in political communication

One of the issues that modern political parties confront is identifying and mobilizing politically disinterested citizens to participate in political activities therefore, communication is critical to the success of a party in garnering voter support and understanding the priorities of citizens. Modern data-driven communications make the customized message a lot more viable alternative, which should boost the effectiveness of political advertising (Witzleb and Paterson, 2021) furthermore, targeted messaging is now a far more feasible choice thanks to modern data-driven communications. Instead of broadcasting the same political advertisement to a wide variety of individuals, campaigns may simply focus on their real and potential constituency, therefore, providing voters

with information that is most relevant to their voting choice (Zuiderveen et al., 2018), this is because when the right message is delivered to the right person (targeted voters) and at the right time, it has the potential of shifting the fate of modern-day data-driven election campaigns including influencing voter outcomes (Bennett, 2018). A metropolitan party, for example, can save money as well as be more effective in its communication by exclusively targeting those who reside in city regions and disregarding apparent rural consumers. Furthermore, social media is now commonly used in political communication to recruit donors and volunteers, specific electorates as well as to track issue engagement (Zuiderveen et al., 2018). Assuming that social media engagement is equally accessible to all players and has a lower overall cost than conventional mass media advertising, this form of campaigning may have the positive effect of lowering entry barriers to the political communication market for smaller parties and allowing parties with limited resources or a more specific message to reach out to constituents (Witzleb and Paterson, 2021).

Psychometric microtargeting and predictive scores

Over the years, Political parties and candidates have been identifying their "voter market" to ensure successful communication with their respective constituencies. This method of classification and segmentation of the "voter market" is known as political microtargeting (Ayankoya et al., 2015). Psychometric profiling is the technique used to infer the personality of an individual based on their actions (Bashyakarla, 2018). According to Mhlomi (2017), Campaigns that employ Micro-targeting stand a higher chance of appealing to the problems that differing voters value most. The political parties can collect extensive data on individual voters' demographic features, consumption patterns, and media choices, and algorithms can track how these aspects correspond with political preference and likelihood to vote. Obama's 2008 campaign, for instance, was tracking over 800 different key voter factors (Northcott, 2020). These microtargeting methods make use of predictive analytics to generate synthetic measures of voter characteristics known as model scores by combining the results from augmented voter files with large survey data. The model scores are used as a criterion for specific voter contact attempts directed at a specific individual (Trish, 2018), this information helps in increasing the efficiency of efforts to communicate with citizens because it is wasteful to target persuasive messaging to citizens who are exceedingly unlikely to vote, even if the persuasive message was successful in persuading them to support the campaign's candidate or issue, this preference shift would be meaningless if the newly persuaded person did not vote (Mude, 2021).

Challenges of Big Data Analytics

Legal system

When running political campaigns, it is not considered forbidden to use the data that has been gathered for the purpose of inferring information about the voter market, however According to Cavaliere et al. (2021), it would require specific authorization in most circumstances under the General Data Protection Regulation (GDPR) in EU Member States. In this regard, the DPAs in the United Kingdom and Italy have issued specific instructions. For instance, The Italian DPA emphasises the need for data subjects to provide informed consent by streamlining consent notices. Furthermore, Cavaliere et al. (2021) note that Data crossmatching and profiling are likely to need consent in France, but Spain appears to prohibit the processing of sensitive personal data even with the data subject's approval. South Africa on the other hand employs the Protection of Personal Information Act (POPIA) which establishes obligatory procedures and methods for the

processing and management of personal information. The Act was also drafted in accordance with the EU directive, it is therefore analogous to the GDPR, however, it also facilitates the cross-border handling and processing of personal information between the EU and SA (Desmond,2021). Cavaliere et al. (2021) also acknowledge that the European data privacy law doesn't quite solve all the electoral or privacy problems nor does it assure that data that is considered to be personal is only used fairly.

Requires specialised skills

According to Anstead (2017), one of the obstacles to implementing data-driven campaigning is managing activists, which also pertains to skills. Furthermore, Dommet (2019) states that the level of customization in profiling enabled by Big Data enables political parties to acquire and consolidate huge amounts of data from various sources, including an increasing emphasis on mining social media platforms. Mude (2021) further adds to this point by stating that these operations are frequently supported by outside data professionals such as the now notorious Cambridge Analytica. This therefore suggests that in some cases, political parties may lack the advisable human resources including the technology to carry out the necessary tasks associated with Big Data analytics, it can also be inferred that data firms in some situations do perform a better job with the resources that they have in comparison to the existing staff employed or present members of the political campaign. This is because according to Dhoodhat (2018), you need to have the necessary skills or capabilities to deal with and extract relevant information from data.

Privacy concerns and data breaches

The public concern over the improper use of personal data is high, especially when data from many sources are linked together. Online microtargeting is comprised of the collection and integration of large amounts of personal data about individuals to be able to infer sensitive information and their political preferences including the Collection of this personal information, for instance, might have a chilling impact, in some cases people who feel that their behaviour is being watched may feel the need to change their behaviour in an attempt to avoid detection. Furthermore, people who are aware or think that their online visits are being recorded may feel uneasy accessing specific websites. For example, People may be hesitant to browse Islam-related websites if they believe an extreme right-wing party will win the elections (Zuiderveen et al., 2018). When it comes to data breaches, many governments throughout the globe have implemented laws requiring data subjects to be notified of the loss or unlawful acquisition of an information resource holding personal information by an unauthorized person. The breadth and requirements of these regulations may vary, and some limit responsibility when data is appropriately encrypted. Many firms that had a breach discovered that the expense of notifying data subjects may be enormous, as can the reputational impact. No organization, including political parties, has been immune to such losses (Bennett, 2016). For example, the ICO (2018) conducted an investigation on Leave.EU and Eldon insurance, after their investigation was concluded, they issued a notice of intent in which they specified that they would both be fined £60 000 each for the major breaches of the PECR (Privacy and Electronic Communications Regulations 2003) which is regarded as the regulations that control electronic marketing. Without authorization Leave.EU subscribers were sent more than one million emails over two distinct periods, including marketing for GoSkippy services.

Used to manipulate/deceive people (improper use of BDA)

Political micro-targeting (PMT), which also echoes problems voiced in the commercial advertising realm, opens the door to potential manipulation, and selective information exposure, and allows campaigns to convey personalized messages straight to individuals therefore evading the potential scrutiny that might come from journalists. As a result, campaigns may make contradictory promises to distinct groups of people without anybody realizing it (Karunian et al., 2019). Furthermore, Zuiderveen et al. (2018) also bring forward Gorton's warning on microtargeting in which they state that Microtargeting turns individuals into manipulatable objects and weakens the public domain by impeding public debate, exacerbating political division, and encouraging the spread of disinformation, they also state that the targeted information does not even have to be factual for it to have the greatest impact.

Big Data challenges

Parimala et al. (2017) conducted a study in which they investigated the challenges and opportunities that come with the use of BDA, some of these challenges include (1) Heterogeneity and incompleteness, (2) scale, (3) timeliness.

How these mentioned challenges relate to the use of BDA in political campaigns is as follows:

Heterogeneity and incompleteness: In some political campaign strategies, political parties make use of social media as a source of data to influence their decision-making. However according to Bak (2016), metadata is considered to be structured data whilst the content displayed is unstructured and according to Parimala et al (2017), some analysis algorithms are designed for uniform data and are incapable of grasping variation. Therefore, as the initial step in data analysis, data must be appropriately processed, however certain incompleteness and some inaccuracies in the data are likely to persist even after the data has been cleaned and the existing errors have been corrected.

Scale: The size of Big Data is a challenge, data-driven political campaigns often collect data on the voter market, for instance with the trump campaign which used the 87 million Facebook data points collected from the "thisisyourdigitallife" app, this data had to be stored somewhere. And, according to Parlina et al (2017), CPU speeds are static, while data volume is increasing faster than available computing capabilities. This means that political parties should consider all these aspects when creating their databases.

Timeliness: According to Parlina et al. (2017) Analysis will take longer as the size of the data collection increases. This therefore means that political parties who wish to collect large data must be able to design a system that is able to effectively deal with size.

Challenges faced by South African political parties

Political apathy

Political Apathy can be defined as the lack of psychological interest or concern for public matters, abstinence from political activity, and emotional detachment from civic engagement (Nweke and Etido-Inyang, 2018). Furthermore, According to Nweke and Etido-Inyang (2018), this can be assessed within the context of voter turnout in the

electoral process. To date, South Africa has seen both the rise and drop in electoral participation, the 2019 elections marked the lowest voter turnout rate since the ending of apartheid and the reintroduction of non-racial participatory democracy, with 63% of voters voting. This was a 26% decrease from the 1999 electoral process which sat at 89% (Schulz-Herzenberg, 2020). Furthermore, Schulz-Herzenberg (2020) suggests that there are two elements that promote psychological engagement in politics, this includes an interest in the election campaign and party identification which are able to mobilize voters to vote. Therefore, this consistent drop in voter turnout raises serious concerns about the quality of civic engagement and citizen involvement in South Africa's democratic politics. It also suggests campaign strategies used by the South African political campaigns need to be further developed, as they are no longer as effective in mobilizing citizens to vote as they once were.

Declining political partisanship and electoral uncertainty

With large parliamentary majorities, the African National Congress, which was a South African liberation movement, that metamorphosed into a political party has been able to rule the nation since 1994. In every general election, the ANC polled more than 55% of the votes during elections (Schulz-Herzenberg, 2019). The continued stay in power of the ANC and voter apathy could be seen in part as a result of partisanship; this is because according to Schulz-Herzenberg (2019) partisans are more inclined to vote and are more likely to vote for their favoured political party. Campbell (1960) has defined the concept of partisanship as the long-term emotive and psychological attachment to one's favoured party that drives voting behaviour. This political mindset however has been on the decrease in the years leading up to the 2019 South African General Elections. The overall effect of the reduction in partisanship led to the fluidity of voter behaviour, which therefore raised the unpredictability/ uncertainty of the 2019 election outcome (Schulz-Herzenberg, 2019). Moreover, Schulz-Herzenberg (2019) states that the dramatic increase in voting abstention accompanied by the drop in aggregate voter participation implies that party identification no longer assures that the electorate will come out in numbers to vote for political parties. The current fluidity of voter behaviour and predictability also suggests that there is a possible need to explore new avenues for predicting voter behaviour during South African electoral seasons.

Uneven political party funding and corruption

Between the years of 2011 to 2017, government reports and parliamentary discussions expressed concerns about the increasing patronage and corruption in South Africa (Brunette, 2019) (Krsteski, 2017) (Ndamase, 2019), These included the contentious R250 million spent on repairing Nkandla, President Jacob Zuma's private residence, which became known as the Nkandla scandal (eNCA, 2016). In the African continent, it is often seen whereby patrons employ governmental resources to guarantee the support or loyalty of the general population. These informal patron and client relationships extend from people at the local level all the way up to the national government and can be traced to ties that exist among political parties and their financiers (Ndamase, 2019). During the South African national and provincial election campaigns in 2019, overall, the political parties as a whole spent more than R2 billion on campaign expenses. Additionally, (Daley, 2021) states that one of the biggest challenges faced by small political parties running political campaigns is raising money to finance the campaign. From the mentioned distribution in campaign financing, it is evident that there is a huge financial gap between the largest political party (ANC) and the smallest or upcoming political parties (DA, EFF, IFP, FF+). One could therefore infer that in situations where small

political parties are unable to raise the same amount of money as the leading political party (ANC) for their campaign as seen in the 2019 South African general elections, they will need to find cheaper but also effective ways to carry out their campaign message that will if not match the leading party, keep up with them.

Failing to capture equal attention of different demographics

Mhlomi (2017) notes that there are five distinct political generations in South Africa's post-apartheid society and further states that Although all South Africans have indeed been shaped by dominant trends within each era, they were also affected in different ways. This, therefore, suggests that what might interest one generation may not necessarily be the other and that there are also differences among people of the same generation. According to Statistics, South Africa's 2018 population projections stood at around 11.7 million eligible voters between the ages of 18 to 29 in the 2019 elections, but only 5.6 million were registered. Older groups, on the other hand, had considerably higher registration rates, with almost 90% of the oldest voters (80+) registered (Schulz-Herzenberg, 2020). These disparities in registered voters for the 2019 elections suggest that South African political campaigns are failing to capture the interest or beliefs of different generations in such a way that they are compelled to vote in large numbers, implying the need for a change in the content or focus of political communication including their communication strategies.

Single-party party dominance

In Africa, most of the countries have been in situations whereby one party possesses an absolute majority of legislative seats and can often govern the country on its own ruling, these parties often continuously dominate the election results over the opposition parties (Bogaards, 2004). However, these dominant parties do not survive forever, as seen by the implosion of the Soviet Communist Party, which was not only dominant but the sole party for most of the time after 1917 (Suttner, 2006). Furthermore, Mtimkulu (2009) states that none of the parties expected to be dominant when they came to power. What mattered was that the next election was won. In South Africa, the ANC has been able to rule the nation since 1994 (Schulz-Herzenberg, 2020). The party has been able to accomplish a lot of things that South Africans are appreciative of, for instance, Nelson Mandela, the party's former president, carried South Africa through the Apartheid transition phase and worked to unify South Africans. Furthermore, the ANC also enjoys considerable national and international legitimacy as a result of its liberation credentials. Unfortunately, the party has not always been a good steward of the confidence or trust that has been bestowed upon it (du Toit, 2014). As a result, the ANC's continuous decrease in popularity and voter support has not come as a big surprise. According to du Toit (2014), this drastic decline suggests that South Africa might be heading toward a more competitive political system. This is potentially positive for opposing parties, as they have the potential to gain more support from voters (especially those lost by the ANC), however, this will only happen if they are to learn from both the negative and positive aspects of the dominating party.

Methodology

The approach that researchers must use to perform their research is known as research methodology (Sileyew, 2019). It is a method that helps researchers come up with, formulate, and analyse their subject of study and/or problem before finally presenting their conclusions based on the information gathered during their investigation. A three-step search strategy was used for this study. First, a preliminary search of EBSCOhost

Research Databases and Web of Science was conducted, using the key concepts Of political parties; political campaigns, and Big Data analytics. The first search was followed by an examination of the text words in the title and abstract of the papers that were retrieved, as well as the index keywords used to describe the articles; this was done to further refine the search approach. The second step was a search across more databases, whereby the improved search strategy that was based on all selected keywords and index terms from the previous step was used. The articles that were retrieved were screened in a two-step process. The first round of screening included the use of the application known as Rayyan (<https://rayyan.qcri.org/>), this is a free web program that could be used to help speed up the process of screening and selecting studies. Using this program helped to reduce duplicates that were retrieved from the various databases, Furthermore, the articles were selected based on their title, keywords, and abstracts. During the second stage of the screening, the articles were assessed for eligibility whereby their full-text versions were read. Articles that did not match the inclusion criteria were not considered. The third step of the three-step strategy was to examine the reference lists of all the indicated articles and reports for additional sources.

The table below represents a summary of the eligibility criteria that were applied to all the articles that were used for this research study. It is important to note that an article did not have to meet all the specified criteria to be considered. An article was only considered if it met criteria five and seven in addition to one other inclusion criterion. Furthermore, if an article meets at least one exclusion criterion it will not be considered for this research study.

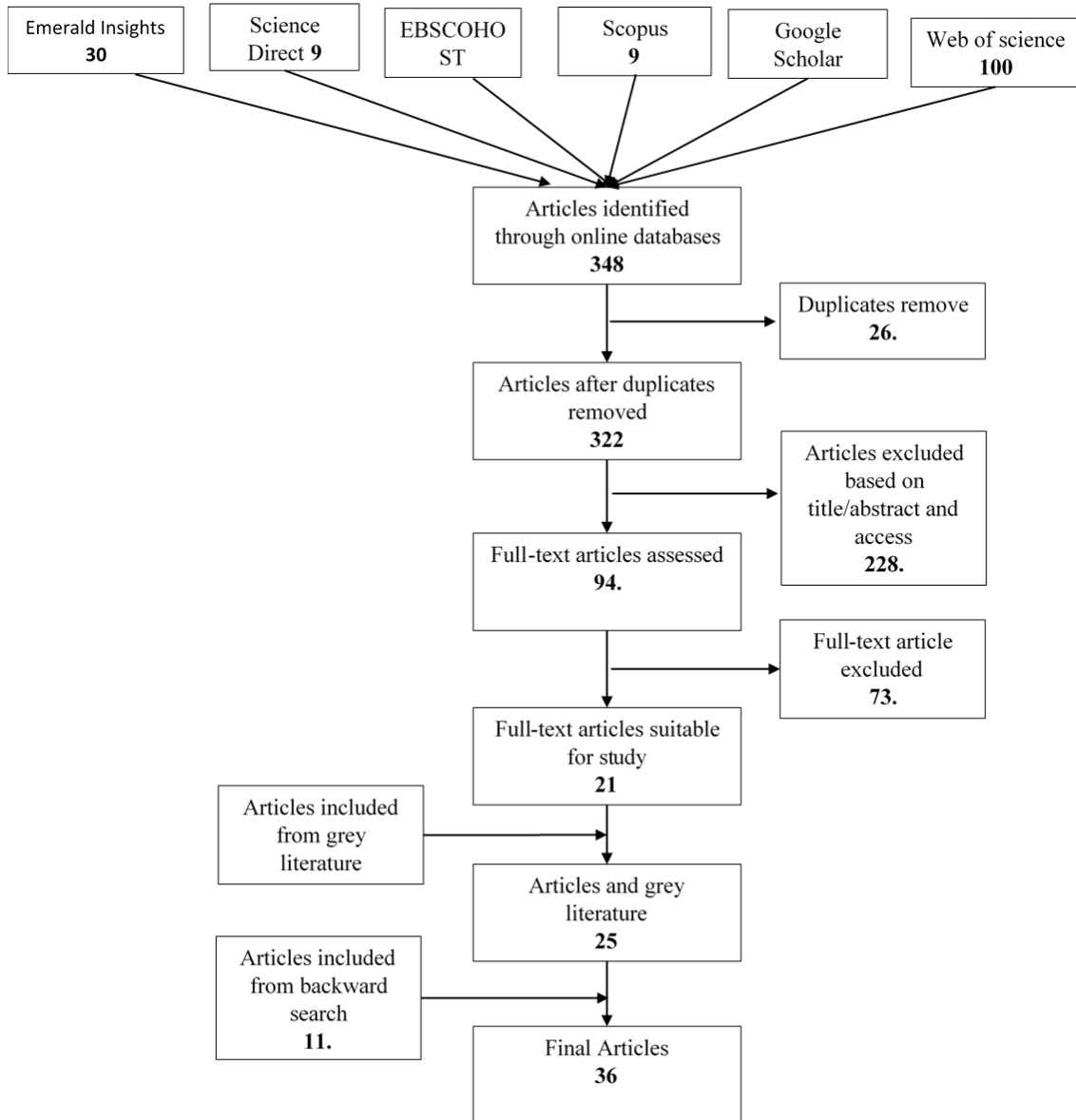
Table 1: Eligibility criteria

Eligibility criteria table

Inclusion criteria	Exclusion criteria
<p>The study must:</p> <ol style="list-style-type: none"> 1. focus on the events that have occurred during political campaigns. 2. examine the adoption, acceptance, or deployment of Big Data Analytics in political campaigns. 3. focus on South African and international campaign strategies and operations used to obtain votes from citizens. 4. Focus on the current issues faced by South African political parties during their campaigns. 5. be written in English only. 6. be published between at least 2016 and 2022, however not excluding classical literature. 7. The paper must be a peer-reviewed study, this however does not apply to the grey literature that is found to be useful for this study. 8. Discuss topics related to Big Data Analytics that are relevant to the research study 	<p>The study must:</p> <ol style="list-style-type: none"> 1. Not have an abstract. 2. Not have a full text available. 3. Be an article that the researcher does not have access to. Be Published earlier than 2016 with minimal insights into the subject matter. 4. Not have been peer-reviewed.

There was a total of 2305 articles that were Retrieved: EBSCOHOST (1513 articles), Web Of Science (452 articles), Science Direct(9 articles), Scopus(9 articles), Emerald Insights(30 articles), Google Scholar(292 articles), however, because the search results were arranged according to relevance, a decision was made to only take the first 100 articles from each database that retrieved more than 100 articles from the search results,

Therefore a total of 348 articles were retrieved for screening. Among these 348 articles, 26 duplicates were removed from the list, an additional 228 Articles were further removed based on the abstract and title, and Articles that met the exclusion criteria were also excluded. These exclusions left 94 articles for full-text evaluation. Following the full-text examination, 21 articles were chosen for this scoping review. There were also an additional 11 articles that were retrieved from backward searches and 4 grey literature articles were also included, therefore resulting in an overall of 36 articles being included in this scoping review. All these steps taken are further represented in a Prisma diagram below.



Results: influence of BDA on political campaign outcomes and IT adoption framework

Benefits of Big Data Analytics

The below diagram (figure 2) shows a summary of the common themes of benefits that are experienced by those political campaigns that employ Big Data Analytics as part of their campaign strategy. Furthermore, the size of each block in this diagram also depicts

the occurrence of each benefit in the papers used. From the diagram below, it is evident that the most common benefit that political campaigns experience is gaining or extracting valuable information from the data that has been collected. However, it is also important to note that some of the benefits shown below depend on this benefit. For instance, you can only make an informed decision after having gained/extracted “valuable” information and you cannot make predictions without having extracted data with trends that might help in guiding those predictions.

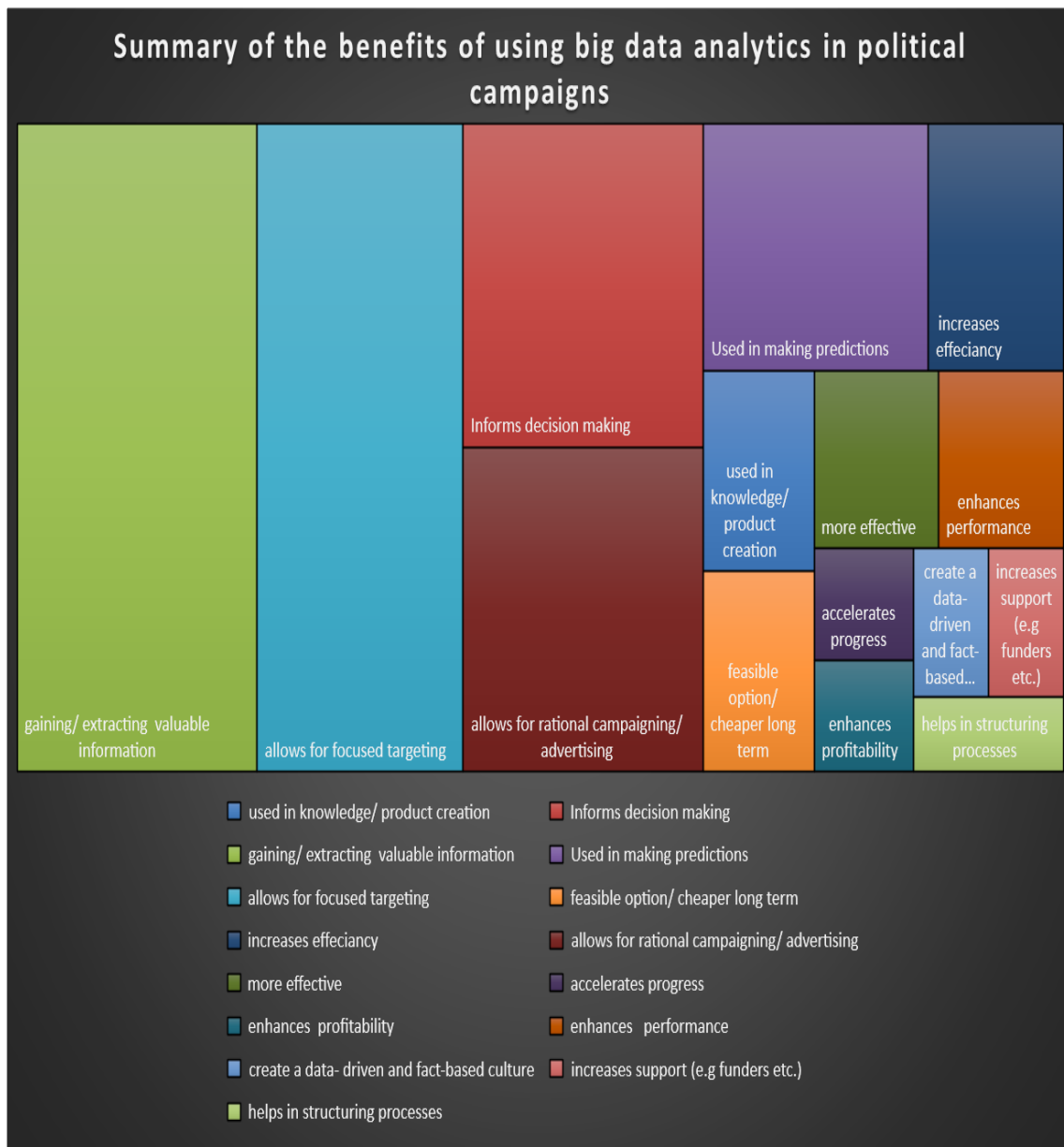


Figure 2: Benefits of using BDA in political campaigns

Based on the literature review, it is evident that the benefits summarised above could address some of the issues that south African political parties are faced with when running political campaigns as shown in the table below:

Table 2: challenges faced by South African political campaigns

CHALLENGES	REFERENCE	BENEFITS OF BDA	REFERENCES
Political Apathy	Nweke et al. (2018) Schulz-Herzenberg (2019) Schulz-Herzenberg (2020)	<ul style="list-style-type: none"> • Informs decision-making. • Allows focused targeting. 	(Bashyakarla,2018). (Dommett, 2019). (Mude, 2021).
Declining Partisanship and electoral uncertainty	Schulz-Herzenberg (2019) Schulz-Herzenberg (2020)	<ul style="list-style-type: none"> • Gaining/ extracting valuable information 	(Zuiderveen et al., 2018) (Witzleb and Paterson, 2021). (Irwansyah et al, 2020)
Failing to Capture equal Attention of different demographics (e.g., youth political participation)	Mhlomi (2017) Schulz-Herzenberg (2020)	<ul style="list-style-type: none"> • Allows for rational campaigning/ Advertising. 	(Karunian et al. 2019) (Yusof et al,2016) (Bennett,2016)
Single party dominance	Nweke et al (2018) Schulz-Herzenberg (2019) Schulz-Herzenberg (2020)	<ul style="list-style-type: none"> • Used to make predictions 	(Papakyriakopoulos et al., 2018) (ICO.,2018) (Anstead, 2017) (Parimala et al, 2017) (Ayokanmbi,2021)
Corruption	Schulz-Herzenberg (2020) Ndamase (2019)		
Uneven political party funding	Ndamase (2019)	<ul style="list-style-type: none"> • Feasible option/ cheaper long term 	(Zuiderveen et al, 2018) (Witzleb et al, 2021)

Challenges of Big Data Analytics and IT Adoption Framework

Summary of BDA Challenges

The below diagram (figure 3) shows a summary of the common themes of challenges faced when using Big Data analytics, more specifically in political campaigns. Furthermore, it is important to note that the size of each block depicts how often the challenge occurred in the papers for this research study (n=36). From the below diagram, the 3 most common challenges that political campaigns are faced with when employing Big Data Analytics as part of their campaign strategy are the “*legal systems*”, this includes everything from the laws of the country which might hinder the level of adoption of BDA in the political campaigns strategies to laws that the campaign strategies must ensure not to violate either on a global scale or just in that country. The second challenge that appeared frequently is the need for skills in this industry, this could range from requiring external companies to facilitate the BDA side of the political campaign to having to train the current staff to help in the decision-making. The third challenge is related to big data, this included the collecting, storing processing, and managing of big data.

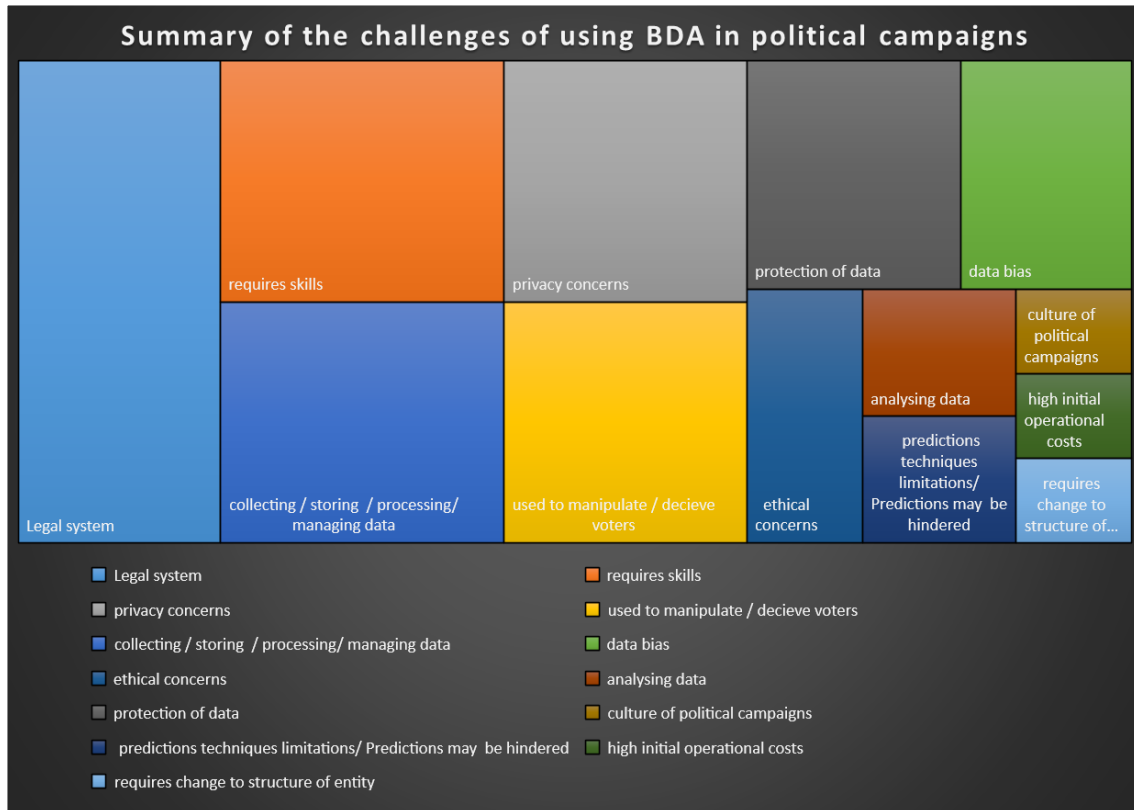


Figure 3: challenges of using BDA in political campaigns

IT adoption framework

Proposed BDA adoption framework for political campaigns

An IT adoption framework refers to a framework that consists of a set of components that drive or affect an organization's decision to adopt a certain technology instrument within its system (Tornatzky and Fleischer 1990). Many frameworks are employed in IS research, however, for this study, primary interest is placed in ideas concerning technology adoption. According to Oliveira and Martins (2011), the TOE and DOI frameworks for adoption models are used at the firm level, and most studies on IT adoption at the firm level are drawn from theories such as these two. Therefore, the focus of This research study is on the TOE AND DOI frameworks. The TOE framework was created in 1990 as a foundational technology adoption framework that is widely utilized in the ICT area (Tornatzky and Fleischer 1990) (Oliveira and Martins, 2011). The framework outlines three components that might have an influence on an organization's adoption and implementation of technological innovation. These components include organizational context, technological context, and environmental context. Furthermore, Diffusion of Innovation (DOI) refers to a theory that is used to describe why, how and at what pace are new ideas and technology spread across cultures at both the firm level and individual. The DOI theory holds that innovations spread through certain channels throughout time and within a specific social system (Rogers 1995). Individuals are perceived to have varying degrees of desire to accept innovations, and hence the proportion of the population adopting an invention is roughly regularly distributed over time. According to Rogers (1995), at the firm level, innovativeness is associated with independent factors such as individual (leader) characteristics, internal organizational structural features, and external organizational characteristics.

The diagram below represents the proposed IT adoption framework for political parties in Africa, particularly South Africa intending to adopt BDA into their campaign strategy, the rationale behind the framework is further explained.

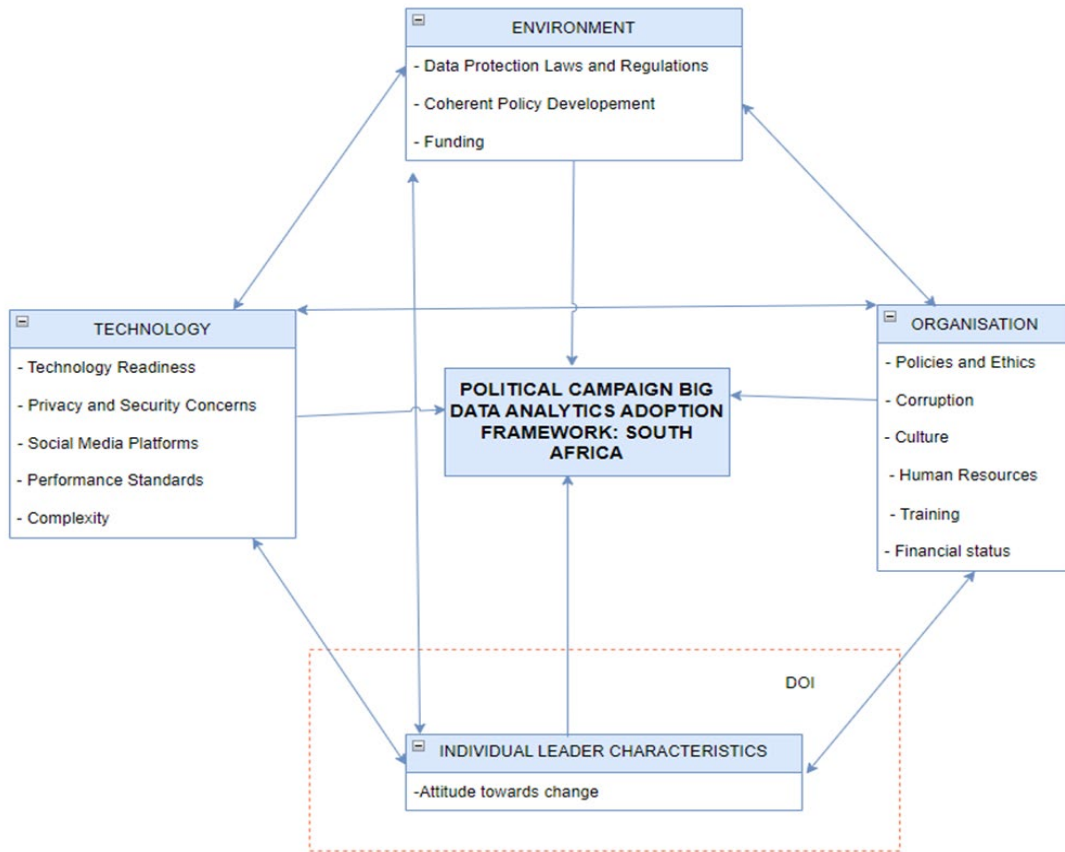


Figure 4: Political campaign BDA adoption framework

Rationale behind the political campaign big data analytics adoption framework: South Africa

The purpose of this proposed adoption framework (Figure 7) is to assist (or serve as a guide for) South African Political parties who wish to incorporate BDA in their campaign strategies. This framework is built using the TOE framework which outlines three components that might have an influence on an organization’s adoption and implementation of technological innovation. These components include organizational context, technological context, and environmental context, Furthermore, the DOI framework was also used in conjunction with the TOE framework, this is because, according to Oliveira et al. (2014), the TOE theory’s perspectives align with Rogers’ (1995) identified innovation characteristics in the DOI framework. This framework (“*political campaign Big Data Analytics adoption framework*”) was developed to address the challenges that were discovered in the literature when conducting the study. The difficulties are categorized according to which TOE and DOI requirements they satisfy. This puts into perspective the factors that need to be considered when incorporating BDA into the campaign strategies of South African political parties, these factors in the technological, organizational, environmental, and individual leader characteristics.

To successfully implement Big Data Analytics in political campaigns, political parties must ask themselves a set of questions regarding their technological, organizational, environmental, and individual leader characteristics. The table below provides an elaboration of the TOE and DOI requirements, as well as the respective attributes and questions to be considered when adopting BDA into a political party's campaign strategy.

Table 3: Political campaign Big Data Analytics adoption framework explained.

REQUIREMENT	DESCRIPTION	FACTORS
Technological	Refers to the Political party's existing technology.	<ul style="list-style-type: none"> • <i>Technology Readiness</i>: Does the political party have the necessary hardware and software to handle the massive amount of data that will be collected and analysed? • <i>Privacy and Security Concerns</i>: Does the political party have the necessary procedures and practices in place to handle the security and privacy of voter data? • <i>Social Media Platforms</i>: what social media platforms is the political party going to use? Do they have permission to conduct their business on the platform? • <i>Performance Standards</i>: Will the particular technology perform to the standard that is required? • <i>Complexity</i>: Is the technology easy to use?
Environmental	Refers to the features that are external from the political party's campaigns however having great influence.	<ul style="list-style-type: none"> • <i>Data Protection Laws and regulations</i>: What Data Protection Laws exist within the country and internationally that the political party must comply with in relation to the data they will use for the campaign? • <i>Coherent Policy Development</i>: What are the policies of the country saying with regard to BDA adoption? What are consequences of non-compliance behaviour? Are they coherent with that of the political party? • <i>Funding</i>: Is the government injecting money into the campaigns?
Organisational	Refers to the domain in which the Political party conducts its business including campaign.	<ul style="list-style-type: none"> • <i>Policies and Ethics</i>: Does the political party have necessary policies with regard to the ethical use of this technology? • <i>Corruption</i>: are there any mitigating strategies to combat fraud and corruption? • <i>Culture</i>: is the political party's existing culture open to embracing the new technology? • <i>Human Resources</i>: Does the political party have the necessary human resources to adopt this technology? • <i>Training</i>: Does the political campaign have programs to train their staff? How much training will the staff require before they can be efficient in the technology? • <i>Financial status</i>: Does the political campaign have the required finances to carry out this technology?
Individual Leader characteristics	Refers to the leader's attitude towards change whilst	<ul style="list-style-type: none"> • <i>Attitude Towards Change</i>: What does the political campaign leader think about incorporating the technology? are they in favour of implementing it? Are the leaders creating an environment that is not stigmatizing the use of technology to IT human resources alone?

Conclusion

Summary

This research study investigated the potential impact that BDA might have on the results of political parties' campaigns in South Africa. According to the assertions made, BDA can theoretically provide a lot of value because of its many advantages and exemplary results in other countries. However, from a practical standpoint, BDA cannot be the sole remedy for all the issues that political parties encounter when conducting their political campaigns.

South African political parties would in fact benefit from the application of BDA in their political campaign strategies through voter profiling and forecasting among other things which will help in influencing voters to vote, therefore increasing the political party's chances of winning elections. However, significant factors like the high initial investment required for the adoption of Political campaign BDA, the variations in data protection laws around the world which are constantly changing, and the need for specialists or trained personnel who are knowledgeable in Political campaign BDA can cause obstacles and significant setbacks for the full embrace of BDA within South African political campaigns.

As this research study was a qualitative study, numerous sources of literature were analysed in generating the discussion. The insights revealed presented a variety of perspectives on the issues encountered by South African political parties; the benefits and challenges associated with Political campaign BDA; and how Political campaign BDA has fared in other countries.

For this investigation, a conceptual framework (figure 4) was also developed. The TOE and DOI adoption models serve as the foundation for this approach. It considers technological, environmental, organizational, and individual leader characteristics, which are then consolidated in accordance with the problems experienced by South African political parties and the obstacles confronted with the use of BDA in political campaigns worldwide.

Limitations

The primary drawback of this study was that it was a qualitative study that solely used desktop research as a data-gathering method. The time allotted to do the research (nearly seven months) was also a constraint, as more detailed research might have been done with greater time. Furthermore, another constraint noted was access to published publications; some of the articles obtained from databases were unavailable to the researcher. Although it was unclear if these articles would have cleared all the subsequent screening phases, they may have offered value in answering the study question.

Future research recommendations

From the research conducted, it is evident that there is not a lot of research done on the adoption of BDA in the campaign strategies of political parties in the African continent. This could suggest that African political parties or candidates are not employing BDA in their political campaigns or that there simply is no published literature in this field. Therefore, it is suggested that future research work should focus on conducting an empirical research project on this area of study. The study should narrow its scope to one (or a few) African nations in order to give a more thorough and saturated view of the

political campaign BDA. Furthermore, studies should look further into the effectiveness of various political campaign technologies that have been used in Africa thus far.

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An evaluation of digital and artificial intelligent tools in an electronic and computer engineering curriculum at a university of technology in South Africa

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Abstract

Digital tools have become integral to higher education, offering a wide array of opportunities for improving the learning experience. This study explores the adoption and impact of digital tools in engineering education. The study employed a mixed-methods approach, utilizing quantitative data and qualitative data collection. Participants included both staff and students in a comprehensive analysis.

The integration of technology in higher education has witnessed significant growth, encompassing educational software, learning management systems (LMS), and online platforms. In engineering education, tools like Moodle, MATLAB, Turnitin, Simulink, and MS Teams have gained prominence (Joksimović & Milosavljević, 2016). However, their effectiveness in achieving educational goals remains to be fully evaluated.

One key advantage of digital tools is personalized learning. Advancements in technology, including artificial intelligence (AI), enable adaptive learning software like ChatGPT to tailor lesson plans based on individual needs.

Furthermore, digital tools expand students' access to resources, such as online lectures, readings, and simulations, supplementing traditional teaching methods. They also facilitate collaborative learning and group projects through platforms like Moodle and Blackboard, enabling effective communication, document sharing, and teamwork.

The findings of this study shed light on the current landscape of digital tools in engineering education. A SWOT analysis is applied to inform future strategies. The study emphasizes the need for a comprehensive evaluation of the effectiveness of these tools and their potential to transform engineering education.

This research contributes to the ongoing dialogue on optimizing digital tools for personalized learning and collaborative education in engineering programs. It underscores the importance of evaluating their impact and tailoring their use to enhance the overall educational experience.

Keywords: *Digital Tools, AI Tools, Moodle, MATLAB, Turnitin, Simulink*

Introduction

There is hardly a facet of life today that has not been impacted by the digitalization process. In other words, modern technology has essentially seeped into every aspect of our society, including education (Devi & Saravanakumar, 2018).

Digital tools can also enhance accessibility and foster inclusivity within higher education. For students with disabilities, assistive technologies, such as text-to-speech software and screen readers can make online course materials more accessible. Moreover, online learning can remove barriers, such as geographic distance, making higher education more accessible to students who cannot physically attend a campus-based institution.

However, the widespread adoption of digital tools in higher education also brings challenges. Students may face technical difficulties or a lack of digital literacy skills, which can hinder their ability to fully participate in online courses. Additionally, there are concerns about unequal access to technology and the digital divide, as some students may not have access to the necessary hardware and Internet connections to fully participate in online learning. Overall, digital tools have the potential to enhance the higher education experience for, both, students and instructors. While challenges exist, the use of digital tools in higher education is likely to continue to grow and evolve as artificial intelligence (AI) technologies have gained momentum. This research conducts an evaluation of digital tools utilized within a university of technology, yielding recommendations that propose a modest framework to cultivate and amplify the implementation of digital and AI tools within the realm of higher education.

Significance of the study

The aim of this research is to evaluate the effectiveness of digital tools, specifically Moodle, MATLAB, Turnitin, Simulink, and MS Teams in an Electronic and Computer Engineering curriculum at a university of technology. The study will focus on the impact of these tools on students' engagement, motivation, understanding of course material, and academic integrity. Through a comprehensive literature review and analysis of existing research, this study aims to provide insight into these digital tools' effectiveness in enhancing engineering students' learning experience.

This research is important as it will provide higher education institutions with valuable information on the effectiveness of digital tools in engineering education and will inform decisions on integrating and using these tools in the future.

- What are the most effective digital tools for facilitating learning in the Department of Electronic and Computer Engineering curriculum?
- How do students and educators perceive the use of digital tools in the electronic and computer engineering curriculum at the university?
- What are their potential challenges with the utilization of digital tools in the electronic and computer engineering curriculum?
- What is the current impact of AI tools in the electronic and computer engineering curriculum at the university?

Literature review

There has been a significant amount of research on the use of digital tools in higher education, with many studies examining the effectiveness of these tools for facilitating learning. One study found that the use of learning management systems, such as Blackboard or Moodle, can lead to improved student outcomes, such as increased retention rates and higher grades (Smith, 2018). Other research has found that virtual reality simulations can be useful for teaching practical skills, such as surgery or engineering (Jones, 2017). Online discussion forums and video conferencing software have also been shown to be effective in facilitating collaborative learning and discussions

among students in more recent times (Wang, 2019). However, some studies have also noted that there can be challenges to the use of digital tools, such as the need for technical support and the potential for a digital divide among students with different levels of access to technology on or off campus (Choi, 2018).

The integration of digital tools in an engineering curriculum in higher education institutions (HEI) has become increasingly important in recent years. Digital tools have the potential to enhance student's learning experiences and improve their employability in the electronic engineering sector.

One of the benefits of using digital tools in an electronic and computer engineering curriculum is the ability to provide students with hands-on experience with industry-standard technology. This allows students to become proficient in using the same tools and software that they will encounter in the workplace (Zebo, 2021). Additionally, digital tools can also enable students to work on more complex projects and simulations, which can enhance their understanding of electronic and computer engineering concepts (Sevara, Shakhriyor & Kosimov, 2022).

However, the integration of digital tools in electronic engineering curricula also presents certain challenges. One of the challenges is the cost of purchasing and maintaining digital tools (JAM van Deursen & AGM van Dijk, 2018). Additionally, there may be a lack of trained teachers and staff to support the integration of digital tools into the curriculum (Sevara, Shakhriyor & Kosimov, 2022).

Digital tools commonly available in a university of technology curriculum

Moodle, an open-source Learning Management System (LMS), has been widely adopted in higher education institutions worldwide. A study found that Moodle improved students' engagement and motivation in online learning environments. The study also noted that the platform's flexibility and customization options make it suitable for engineering education (Joksimović & Milosavljević, 2016).

MATLAB, a numerical computing environment, and programming language is frequently used in engineering education. A study evaluated the effectiveness of using MATLAB in teaching control systems to students studying engineering (Ozkan & Kose, 2018). They found that students who used MATLAB performed better on exams and had a deeper understanding of the course material compared to students who did not use the software.

Turnitin, a plagiarism detection software, has been used in higher education institutions to promote academic integrity. A study examined the effectiveness of Turnitin in reducing plagiarism among engineering students. The authors found that the use of Turnitin led to a significant decrease in plagiarism incidents among students (Van der Meijden, 2018).

Simulink, a block diagram-based simulation and model-based design environment, is widely used in the teaching of control systems in engineering education. A study found that using Simulink in teaching control systems improved students' understanding of the subject matter and their ability to apply control theory concepts (Ozkan & Kose, 2019).

MS Teams, a collaboration, and communication platform has been found to be effective in enhancing students' engagement and motivation in online learning (Yen &

Nhi, 2021). The use of MS Teams in engineering education has been found to increase students' participation in online discussions and group projects, leading to improved collaboration and communication skills (Buchal & Songsore, 2019). Furthermore, MS Teams have been found to foster a sense of community among students, leading to increased motivation and engagement in the learning process (Yen & Nhi, 2021).

Studies have indicated that the integration of MS Teams into engineering education can result in enhanced comprehension of course content. For instance, the utilization of MS Teams for activities like peer feedback and self-reflection has been associated with increased performance on examinations (Yin & Wang, 2017) and a better understanding of complex engineering concepts (Koh & Lim, 2018).

Artificial Intelligence in Higher Education

Artificial intelligence (AI) has been making its way into the field of education, and higher education, in recent years. AI-powered tools have the potential to revolutionize the way students learn and how educators teach. This literature review will summarize some of the most significant and recent studies on the use of AI tools in higher education.

A review of the literature has shown that AI tools have been used in higher education to enhance personalized learning experiences, improve student assessment, and support teaching and learning processes. For instance, AI-powered recommendation systems have been used to provide personalized learning pathways to students based on their learning styles and previous performance (Limna, Jakwatanatham, Siripipattanakul, Kaewpuang, & Sriboonruang, 2022). Additionally, AI tools have been used to grade student assignments, essays, and exams, reducing the time and effort required for teachers to grade large numbers of submissions (Zhou, 2019).

Furthermore, AI-powered tutoring systems have been used to provide individualized feedback and support to students, thereby improving their learning outcomes (Escotet, 2023). AI tools have also been used to analyse large amounts of data and generate insights that can inform teaching and learning practices (Escotet, 2023). Further research has shown that AI-powered virtual tutors in higher education can provide students with personalized feedback, which can help to improve their learning outcomes (Duhaney & Parekh, 2020). However, they also noted that there is a need for further research on the effectiveness of virtual tutors in different subjects and for different types of learners.

An investigation into the use of AI in personalized learning in higher education has found that AI-powered personalized learning can significantly improve students' learning outcomes and motivation (Chen & Liang, 2020). Recently AI has been used for instructions and assessment of students in higher education. It was found that AI can provide objective and accurate assessments, which can help to reduce human bias in grading (Ouyang, et al., 2022). It was also noted that the use of AI in assessment can help to save time and resources for educators (Al-Shawabkeh & Alshamari, 2021).

ChatGPT was created by the US-based business OpenAI. This state-of-the-art chatbot was trained using deep learning techniques and a substantial amount of Internet text data. GPT, or generative pretrained transformer, can comprehend human-provided inputs and generate text in response that is remarkably like human language, making it nearly impossible to distinguish the difference between human and AI-generated text. DALL-E and ChatGPT are two of the most well-known machine learning (ML) products that

OpenAI has made available to the public. Researchers have started looking into the effects and difficulties that ChatGPT would bring to the education sector, notably at the tertiary level, since it was launched in November 2022 (Rasul, Nair, Kalendra, Robin, de Oliveira Santini, Ladeira, Sun, Day, Rather & Heathcote, 2023).

Benefits of ChatGPT in Higher Education Institutions (Rasul, et al., 2023):

1. Personalized learning experiences.
2. Customized feedback for each learner.
3. Assistance with research, writing, and data analysis tasks.
4. Streamlined administrative tasks through automation.
5. Creative and novel assessment methods.

Challenges of ChatGPT in higher education (Rasul, et al., 2023):

1. Ethical and fairness concerns.
2. Upholding academic honesty.
3. Possible bias and the risk of processing inaccurate information.
4. Evaluating the skill sets of graduate students.
5. Measuring the learning achievements of students.

The key distinctions between digital tools and AI tools

A digital tool is a device or application that uses technology to perform specific tasks, automate processes or provide information. These tools can range from simple applications, like calculators and note-taking software to complex systems, like enterprise resource planning (ERP) systems. Digital tools do not have the capability to learn or make decisions on their own and instead rely on pre-programmed instructions and algorithms to perform their functions (Gartner, 2021).

On the other hand, AI tools are a subset of digital tools that incorporate artificial intelligence to perform certain tasks. AI tools use machine learning algorithms to analyze data, identify patterns, and make predictions or decisions based on that analysis. This allows AI tools to continually improve and adapt to changing data, making them more effective over time. Unlike digital tools, AI tools can self-learn, improve, and evolve their decision-making abilities without human intervention (Techopedia, 2022).

The key difference between digital tools and AI tools lies in their level of autonomy and ability to learn. While both are valuable in their own ways, AI tools have the added advantage of being able to continuously improve and adapt to new data, making them well-suited for tasks that require decision-making or prediction (Investopedia, 2021).

Methodology

Research strategy

To address the research questions, a mixed-methods approach was used, including both qualitative and quantitative data (Creswell, 2013). A survey was administered to a sample of educators at the faculty of engineering in a university of technology to gather data on their perceptions and experiences with digital tools in higher education. In addition, focus groups were conducted with a sample of students to gather more in-depth insights on their use of digital and AI tools (Creswell & Plano Clark, 2011).

The research philosophy for this study is pragmatism, pragmatism permits the prospective and possibility to work between qualitative data and quantitative data (Kelly & Cordeiro, 2020).

Data collection

A total of 30 staff participated in the study at the Electronic and Computer Engineering Department. During phase 1, qualitative data was collected through semi-structured interviews with staff for a SWOT analysis. The data was analyzed using thematic analysis to identify common themes and patterns (Teddlie & Yu, 2007). During phase 2, quantitative data was collected through an online survey that was distributed to a sample of 30 staff at the Electronic and Computer Engineering Department. During phase 3 a separate online survey was given to 498 students at the Electronic and Computer Engineering Department. These surveys were designed to gather information on the types of digital and AI tools that are being utilized, their perceived benefits, and the challenges faced in their implementation. The data was analyzed using descriptive statistics to determine the average mean of the response outputs. (Neuendorf, 2016). The decision to use only the average mean in this analysis was to keep the analysis straightforward, easily interpretable, and within the time constraints of the study. The average mean provides a concise summary of the central tendency of the Likert scale responses. By focusing solely on the average mean, it presented a clear and concise overview of the participant's overall level of agreement or disagreement with the statements.

Analysis and results

Quantitative outputs:

The response from the staff survey were presented in Table 1. The average mean was determined, and the corresponding output was displayed for each statement.

Table 1. Staff Response

Questions	Average Mean	Response output
I frequently utilize digital tools for teaching and learning in my modules.	4,62	Strongly Agree
I have been adequately trained in the various digital tools used in my organization.	3,15	Neutral
There is effective technical support for digital tools in my organization.	3,54	Agree
A digital tool that I frequently use for teaching and learning in my module is Moodle.	3,92	Agree
A digital tool that I frequently use for teaching and learning in my module is MATLAB™.	3,54	Agree
A digital tool that I frequently use for teaching and learning in my module is MS Teams.	3,92	Agree
A digital tool that I frequently use for teaching and learning in my module is Multisim™.	4,54	Strongly Agree
A digital tool that I frequently use for teaching and learning in my module is Turnitin.	2,00	Disagree
The digital tools used in my module are sufficient in meeting the objectives of my module.	4,38	Strongly Agree
I rarely have encountered any technical difficulties while using digital tools.	3,46	Agree
Digital tools have enhanced the quality of my module in an engineering curriculum.	4,15	Agree
Digital tools are effective in replacing traditional practical's done in laboratories and workshops.	3,31	Neutral
Digital tools are effective in research-based outputs.	4,31	Strongly Agree
I prefer utilizing digital tools in my pedagogic approach to traditional methods.	4,54	Strongly Agree

The responses from Table 1 provides insights into the staff's perceptions and experiences regarding the use of digital tools and AI in an engineering curriculum. The analysis of responses was summarized in Table 2:

Table 2. Analysis of Staff Responses

Topic	Descriptive Analysis
Utilization of Digital Tools	Most staff (indicated by "Strongly Agree") frequently use digital tools for teaching and learning in their modules. This suggests a high level of engagement and reliance on technology for instructional purposes.
Training on Digital Tools	Staff members have a neutral opinion on the adequacy of training received for various digital tools. This implies that there might be a need for further training or improvement in the training programs to ensure staff members feel confident in using the tools effectively.
Technical Support	The staff generally agrees that there is effective technical support available for digital tools in the organization. This indicates that the institution has taken measures to aid staff members when they encounter technical difficulties.
Frequently Used Digital Tools	The digital tools most frequently used by staff members for teaching and learning in their modules include Moodle, MATLAB™, MS Teams, and Multisim™. These tools are considered valuable for instructional purposes and are likely integrated into the curriculum effectively.
Turnitin Usage	Staff members disagree that they frequently use Turnitin, indicating that this specific tool might not be as commonly utilized in their modules. The reasons for this disagreement could vary, such as the nature of the modules or alternative methods used for plagiarism detection.
Sufficiency of Digital Tools	Staff members strongly agree that the digital tools used in their modules are sufficient in meeting the objectives. This indicates that the current selection of tools aligns well with the desired learning outcomes and instructional goals.
Technical Difficulties	Staff members generally agree that they rarely encounter technical difficulties while using digital tools. This suggests that the institution's IT infrastructure and support mechanisms are effectively managing technical issues, minimizing disruptions during teaching and learning activities.
Enhancement of Module Quality	Staff members agree that digital tools have enhanced the quality of their modules in the engineering curriculum. This positive perception indicates that the integration of technology positively impacts the learning experiences and outcomes for students.
Replacement of Traditional Practical Activities	The staff members have a neutral opinion on the effectiveness of digital tools in replacing traditional practical activities conducted in laboratories and workshops. This suggests that while digital tools have their advantages, they might not completely replace hands-on experiences in certain aspects of engineering education.
Effectiveness in Research-based Outputs	Staff members strongly agree that digital tools are effective in research-based outputs. This suggests that the tools enable staff members and students to conduct research activities efficiently, contributing to the institution's research goals.
Preference for Digital Tools	Staff members strongly agree that they prefer utilizing digital tools in their pedagogic approach compared to traditional methods. This indicates a positive attitude towards the integration of technology and a recognition of its benefits in teaching and learning.

The response from the student survey were presented in Table 3. The average mean was determined, and the corresponding output was displayed for each statement.

Table 3. Student Responses

Questions	Average Mean	Response output
I often use digital tools in my engineering modules.	3,36	Agree
I feel the integration of digital tools enhances the engineering curriculum.	3,9	Agree
I frequently use Moodle in my module.	1,92	Agree
I frequently use MATLAB in my module.	4,38	Strongly Agree
I frequently use MS Teams in my module.	5,44	Strongly Agree
I frequently use Simulink in my module.	6,94	Strongly Agree
I frequently use Turnitin in my module.	2,22	Agree
Digital tools help improve my understanding of engineering concepts.	4,38	Strongly Agree
The digital tools provided by the university are sufficient for my learning needs.	5,04	Strongly Agree
I have been adequately trained in digital tools used in my engineering qualification by the university.	4,86	Strongly Agree
I feel comfortable using digital tools for engineering practicals.	2,46	Agree
Digital tools are vital for me to complete my assignments and projects in my engineering qualification.	5,8	Strongly Agree
I use digital tools for lecture attendance and communication.	7,456	Strongly Agree
I have adequately improved my skills in digital tools since studying for my engineering qualification.	8,544	Strongly Agree
I prefer using digital tools rather than traditional methods in my engineering qualification.	4,236	Strongly Agree

The responses from Table 3 provide insights into the student’s perceptions and experiences regarding the use of digital tools and AI in an engineering curriculum. The analysis of responses was summarized in Table 4:

Table 4. Analysis of Student Responses

Topic	Descriptive Analysis
Utilization of Digital Tools	The majority of students agree that they often use digital tools in their engineering modules. This suggests that students actively engage with technology to support their learning and academic activities.
Enhancement of Engineering Curriculum	Students agree that the integration of digital tools enhances the engineering curriculum. This indicates that the incorporation of technology positively impacts their learning experiences and contributes to a more effective curriculum.
Usage of Moodle	Students frequently use Moodle in their modules, indicating that the learning management system plays a significant role in their education. Moodle likely supports various aspects of their coursework, such as content delivery, assignment submissions, and communication.
Usage of MATLAB	Students strongly agree that they frequently use MATLAB in their modules. MATLAB is widely recognized as a valuable tool in engineering disciplines, particularly for numerical analysis, simulation, and data visualization.
Usage of MS Teams	Students strongly agree that they frequently use MS Teams in their modules. MS Teams provides a platform for collaboration, communication, and online meetings, enabling students to engage with peers and instructors effectively.
Usage of Simulink	Students strongly agree that they frequently use Simulink in their modules. Simulink is a powerful tool for modelling and simulating dynamic systems, which aligns well with engineering coursework that involves control systems, signal processing, and more.

Usage of Turnitin	Students agree that they frequently use Turnitin in their modules. Turnitin is commonly used for plagiarism detection and originality checking, indicating that academic integrity is valued in their coursework.
Improvement of Understanding	Students strongly agree that digital tools help improve their understanding of engineering concepts. This suggests that technology aids their comprehension and enables them to grasp complex ideas more effectively.
Sufficiency of Digital Tools	Students strongly agree that the digital tools provided by the university are sufficient for their learning needs. This implies that the institution has invested in appropriate and comprehensive tools to support the students' engineering education effectively.
Training on Digital Tools	Students strongly agree that they have been adequately trained in the digital tools used in their engineering qualification. This indicates that the university has provided sufficient training to ensure students are proficient in utilizing these tools.
Comfort with Engineering Practicals	Students generally agree that they feel comfortable using digital tools for engineering practicals. This suggests that the students are confident in applying digital tools in hands-on scenarios and practical applications within their coursework.
Importance of Digital Tools for Assignments and Projects	Students strongly agree that digital tools are vital for them to complete their assignments and projects. This underscores the significance of technology in facilitating their academic tasks and achieving successful outcomes.
Usage of Digital Tools for Lecture Attendance and Communication	Students strongly agree that they use digital tools for lecture attendance and communication. This highlights the role of technology in facilitating remote or online learning, as well as fostering effective communication between students and instructors.
Improvement in Digital Tool Skills	Students strongly agree that they have adequately improved their skills in digital tools since studying for their engineering qualification. This indicates that the use of digital tools in the curriculum has contributed to their personal growth and technical proficiency.
Preference for Digital Tools over Traditional Methods	Students strongly agree that they prefer using digital tools rather than traditional methods in their engineering qualification. This demonstrates a positive attitude towards technology and its superiority in supporting their learning and academic endeavours.

SWOT Analysis:

Table 5 presents a summary of the SWOT analysis of the staff responses from the data collection.

Table 5. Summative Analysis of the Staff SWOT Responses

Strengths	Weaknesses
<ul style="list-style-type: none"> • Improved Learning Outcomes: Digital and AI tools can help personalize learning experiences and deliver content tailored to individual student needs, leading to improved learning outcomes. • Increased Efficiency: Digital and AI tools can automate administrative tasks such as grading, scheduling, and record keeping, freeing up faculty and staff time for other tasks. • Enhanced Collaboration: Digital and AI tools can facilitate collaboration between students and faculty, as well 	<ul style="list-style-type: none"> • Implementation Challenges: Implementing digital and AI tools in higher education can be challenging, especially for smaller institutions with limited resources. • Data Privacy Concerns: There may be concerns about the privacy of student data when using digital and AI tools, as well as issues around data ownership and control. • Cost: Implementing digital and AI tools can be expensive, and institutions may need to invest in new infrastructure and/or software licenses.

<p>as between students themselves, improving the learning experience.</p> <ul style="list-style-type: none"> • More Effective Teaching: Digital and AI tools can provide real-time feedback to instructors, enabling them to adjust their teaching style and course content to better meet student needs. 	<ul style="list-style-type: none"> • Limited Understanding: Some faculty and staff may be resistant to using digital and AI tools in the classroom due to a lack of understanding or comfort with the technology. • AI tools like ChatGPT may remove the human touch from learning. • AI tools like ChatGPT may have limited data and provide misinformation, especially in technical content.
Opportunities	Threats
<ul style="list-style-type: none"> • Improved Access: Digital and AI tools can help to democratize education by providing access to resources and support for students who might not otherwise have access to them. • Enhanced Learning Analytics: Digital and AI tools can provide insights into student behaviour and performance, enabling instructors to better understand student needs and adjust their teaching accordingly. • Collaboration: Digital and AI tools can facilitate collaboration between institutions, enabling them to share resources and expertise. • New Research Opportunities: AI tools such as ChatGPT can enable researchers to explore new areas of inquiry and gain insights that might not be possible with traditional research methods. Quillbot can help researchers save time when summarizing the content of journal literature. 	<ul style="list-style-type: none"> • Bias: There is a risk that digital and AI tools may perpetuate or even amplify existing biases, such as racial or gender bias if they are not designed and implemented carefully. • Dependence: There is a risk that institutions may become overly dependent on digital and AI tools, leading to a loss of critical thinking and decision-making skills among faculty and staff. • Job Displacement: AI tools may automate tasks that were previously performed by human staff, potentially leading to job displacement or retraining needs. • Security Risks: There may be security risks associated with the use of AI tools, such as data breaches or hacking attempts. • AI tools such as ChatGPT introduces ethical concerns and misuse during assignments and assessments.

Discussion of analysis

The survey findings shed light on the effectiveness of digital tools in the electronic and computer engineering curriculum. Notably, staff identified Moodle, MATLAB, MS Teams, and Multisim as the most valuable tools for facilitating learning. These tools appear to play a pivotal role in the curriculum, underscoring their significance.

Both staff and students expressed positive perceptions of digital tools in the curriculum. Staff prefer digital tools over traditional methods, while students credit them with improving their understanding of engineering concepts. However, the replacement of traditional practical activities with digital tools warrants further exploration, as some staff members remain neutral on this issue.

While recognizing the potential of digital tools, staff also highlighted challenges. They emphasized the need for additional training to enhance their proficiency. Furthermore, concerns regarding data privacy, ownership, and biases in AI tools are significant, emphasizing the importance of addressing these issues.

Regarding AI tools, staff expressed apprehensions about their impact on the human element of learning and their potential for providing inaccurate technical information. Ethical concerns and the risk of misuse in assignments and assessments underscore the need for careful monitoring and support in their implementation.

In summary, the survey results offer valuable insights into the current landscape of digital and AI tools in the electronic and computer engineering curriculum. While strengths and opportunities exist for further enhancement, addressing training needs, data privacy, and ethical considerations is vital. The findings emphasize the need for a balanced approach to maximize the benefits of digital and AI tools while mitigating potential challenges.

Conclusion and recommendations

In conclusion, the survey results indicate that staff members in the institution frequently utilize digital tools in their modules for teaching and learning. Most staff members perceive these tools as valuable, effective, and capable of enhancing the quality of modules and research-based outputs. While there is a need for further training and improvement in technical support, the overall feedback is positive, suggesting a successful integration of digital tools into the engineering curriculum.

Supporting the staff survey outcomes, are the student's survey which indicated that the institution actively utilizes digital tools in its electronic and computer engineering curriculum. The integration of these tools is perceived to enhance the curriculum, supporting a deeper understanding of engineering concepts and improving the overall learning experience. The students frequently use specific digital tools such as Moodle, MATLAB, MS Teams, Simulink, and Turnitin, indicating their importance in various aspects of their coursework. The students find the digital tools provided by the university to be sufficient for their learning needs and feel adequately trained in utilizing these tools. They express comfort in using digital tools for practicals, assignments, and projects, emphasizing their vital role in completing academic tasks. Additionally, digital tools are preferred over traditional methods, and their usage extends to lecture attendance and communication. Overall, the students' positive perception of digital tools reflects their recognition of the benefits and effectiveness of technology in their engineering qualification.

The use of digital and AI tools in higher education institutions presents various strengths, weaknesses, opportunities, and threats. AI tools offer improved learning outcomes by personalizing educational experiences and increasing efficiency through automating administrative tasks. They also enhance collaboration among students and faculty, leading to a more effective teaching environment. However, challenges exist, including implementation difficulties for smaller institutions with limited resources, concerns about data privacy, and the cost of acquiring and integrating AI tools. Additionally, some faculty and staff may exhibit resistance due to a lack of understanding or comfort with the technology, while concerns arise about the potential loss of the human touch in learning and the limited data accuracy and misinformation provided by AI tools like ChatGPT.

Nevertheless, opportunities emerge in terms of improved access to education, enhanced learning analytics, collaboration between institutions, and new research opportunities. On the other hand, threats encompass potential biases, dependence on AI tools leading to a decline in critical thinking skills, job displacement, and security risks. Ethical concerns and potential misuse during assessments also come to the forefront when implementing AI tools, such as ChatGPT.

This research study recommends the following for higher education institutions on digital and AI tools in Table 6:

Table 6. Recommendations on a Digital and AI Tools Framework

Topic	Recommendation
Promote Continuous Training and Technical Support	Recognizing the need for further training and improvement in technical support, it is crucial for higher education institutions to invest in professional development programs for faculty and staff. This will enhance their competency in utilizing digital and AI tools effectively in their teaching and research activities.
Address Implementation Challenges	Smaller institutions with limited resources may face difficulties in implementing digital and AI tools. It is recommended to explore partnerships or collaborations with larger institutions or technology providers to share resources and expertise. Additionally, identifying funding opportunities or seeking grants specifically for implementing digital and AI tools can help overcome financial barriers.
Prioritize Data Privacy and Security	To address concerns about data privacy and security risks, institutions should establish clear policies and protocols for handling student data when using digital and AI tools. This includes ensuring compliance with relevant regulations and implementing robust cybersecurity measures to safeguard sensitive information.
Foster Faculty Engagement	Overcoming resistance to digital and AI tools requires active engagement and support from institutional leadership. Encourage faculty to participate in workshops, seminars, and conferences focused on technology integration in education. Promote a culture of innovation and provide incentives for experimentation and adoption of new digital and AI tools.
Balance Technology and Human Touch	While digital and AI tools offer numerous benefits, it is essential to strike a balance between technology and the human touch in higher education. Emphasize the importance of critical thinking, problem-solving, and interpersonal skills alongside the use of digital and AI tools. Encourage faculty to incorporate interactive activities and discussions in their teaching methods to maintain student engagement and foster a holistic learning experience.
Collaborate for Research and Development	Institutions should actively seek opportunities for collaboration with other institutions, industry partners, and researchers to explore new research avenues and improve the effectiveness of digital and AI tools in higher education. This collaboration can lead to the development of innovative tools and methodologies that address the specific needs of students and faculty in different disciplines.
Conduct Regular Evaluations	Continuously assess the effectiveness and impact of digital and AI tools on learning outcomes. Gather feedback from students and faculty through surveys, focus groups, or interviews to identify areas of improvement and make informed decisions about future technology integration initiatives.

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Prof Pi: GPT-4 tutoring mathematics in African languages

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Abstract

Artificial intelligence has been used in many industries already. With the advent of artificial intelligences such as chatGPT, however, which can consume and generate text which is very similar to text which a human being would generate, it is time that artificial intelligence moves into education. Even more important than moving into general education, artificial intelligences such as chatGPT have multi-lingual abilities and can operate with non-English prose. This paper looks at a GPT-based mathematics tutoring bot called Prof Pi. The tutoring bot uses GPT-4 (the underlying API behind chatGPT Plus) in the backend to consume questions from learners and students about mathematics and generate conversations about mathematics topics. This paper summarises some of the previous research about Prof Pi with non-English languages used in Africa. The paper then specifically looks at the use of this mathematics tutoring bot using the Zulu language.

Keywords: Prof Pi, Mathematics, Whatsapp, GPT-4, chatGPT

Introduction

In a 2020 publication, Kshetri itemised a number of industries where artificial intelligence is already operating in developing countries. These industries include agriculture, mining, energy, transportation, healthcare, finance and human resource development (Kshetri 2020). Interestingly, Kshetri's list of industries did not include education.

Ouyang and Jiao, on the other hand, look at how artificial intelligence has been used specifically in education (but not necessarily the developing world). They describe three paradigms in using artificial intelligence in education: 1) AI-directed where the learner is merely a recipient of information 2) AI-supported where the learner is a collaborator with the artificial intelligence and 3) AI-empowered where the artificial intelligence empowers the learner to take the lead in his or her learning (Ouyang and Jiao 2021).

Prof Pi is an artificially intelligent mathematics tutoring bot which spans the first and second paradigms as defined by Ouyang and Jiao. As part of the first paradigm, Prof Pi provides information to the learner. In addition, however, as part of the second paradigm, Prof Pi expects the learner to do part of the work of learning and Prof Pi collaborates with the learner by asking questions and expecting answers from the learner. Prof Pi acts as a Socratic tutor asking questions to guide the learner or student to finding the answer to his or her own question.

Being based on GPT- n (where n is a version number and at the time of writing this paper, Prof Pi was based on GPT-4), Prof Pi communicates with learners in any of the human languages which GPT- n supports. This paper summarises previous research by the author looked at how Prof Pi communicated with learners using Arabic and Afrikaans. This paper also mentions on-going research with Prof Pi communicating in Kiswahili and Amharic. This paper then presents new research specifically looking at the evaluation of Prof Pi operating in the Zulu language.

The Background section provides supporting information and literature about artificial intelligence. The Prof Pi section provides technical information about how Prof Pi works and summarises previous and on-going research about Prof Pi. The Methodology section describes how the research reported in this paper was conducted. The Ethics section discusses any ethical issues which might have arisen on this research project. The Results section provides the results of the experiments. And concluding remarks are found in the Conclusion section.

Background

The expression *artificial intelligence* means different things to different people. The first documented use of the expression was in August, 1955, when McCarthy *et al* proposed “that a 2 month, 10 man study of artificial intelligence be carried out during the summer of 1956 at Dartmouth College in Hanover, New Hampshire.” Their rather intrepid goal was to “[attempt] to find how to make machines use language, form abstractions and concepts, solve kinds of problems now reserved for humans, and improve themselves” (McCarthy et al. 1955).

Much has happened in the 68 years from that proposal to the current day (August, 2023). In December, 2015, a number of Silicon Valley investors founded an artificial intelligence research center called OpenAI. OpenAI had a long range goal of creating an artificial general intelligence which would be capable of performing an intellectual task which a human could perform (Markoff 2015). In late 2022, OpenAI opened a website called chatGPT where people could ask questions using normal human prose and receive answers in prose in a form which appeared remarkably human (OpenAI 2022).

In March, 2023, chatGPT Plus was released and GPT-4 was released. ChatGPT Plus is the enhanced website and GPT-4 is the latest programmer API which supports chatGPT Plus. According to OpenAI’s own technical report on GPT-4, GPT-4 does remarkably well at standard tests. In the case of a simulated legal bar examination, GPT-4 placed in the top 10% of students taking the examination. In the case of the SAT evidence-based reading and writing examination, GPT-4 placed in the 93 percentile. In the verbal portion of the GRE, GPT-4 placed in the 99 percentile (OpenAI 2023). With results like those, GPT-4 needed to move into education.

Prof Pi

Prof Pi is a mathematics tutoring bot which uses OpenAI’s GPT-4 API to consume questions from the learners and students and generate responses. The learners use the popular Whatsapp chat system on their cell phones. An overview of the architecture can be seen in Figure 1.

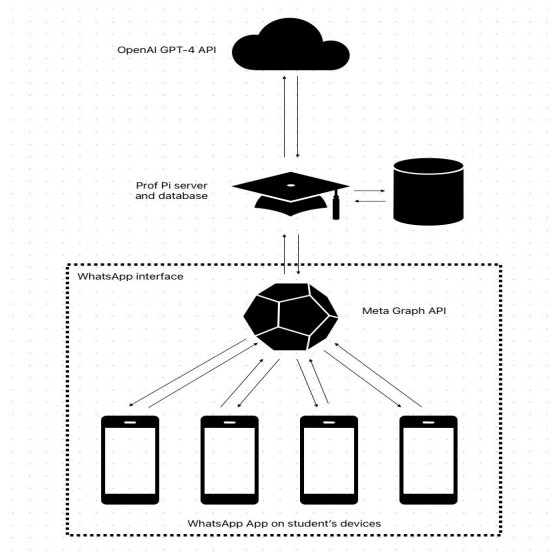


Figure 3: Architecture of Prof Pi

Learners on their cell phones use Whatsapp which communicates with the Meta Graph API. The Meta Graph API handles all the Whatsapp logistics and forwards messages to the Prof Pi server. The Prof Pi server checks various configurations and permissions. The Prof Pi server then writes to log files and forwards the messages onto GPT-4. GPT-4 processes the messages and generates responses which follow the same path in reverse back to the specific learner who originally sent the message. A sample conversation snippet can be seen in Figure 2.

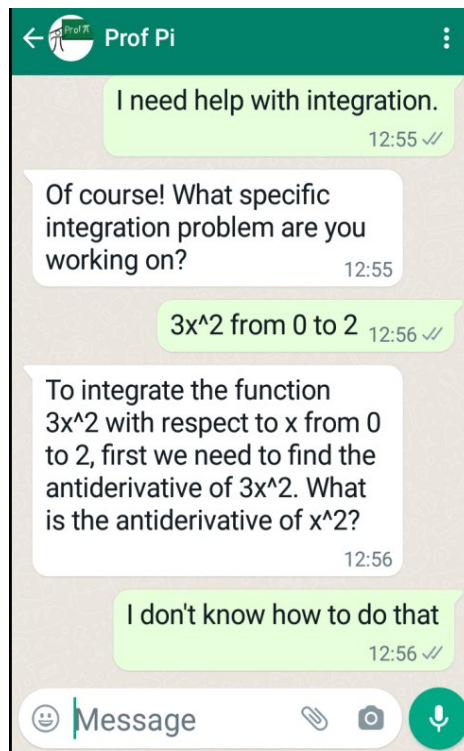


Figure 4: Sample conversation with Prof Pi

The GPT-4 Technical Report explains that GPT-4 was trained using both publicly available data such as internet data and data which was licensed from third-party providers (OpenAI 2023). The Technical Report, however, does not give the specific details on how much data was used to train GPT-4. Wired Magazine, however, reports that when Sam Altman (the CEO of OpenAI) was asked at an event at MIT whether the training of GPT-4 cost US\$100 million, he replied “It’s more than that” (Knight, Will 2023).

Being trained on internet data implies that GPT-4 was trained on data which was not necessarily written English. However, not all human languages are equally available on the internet. (Zoph et al. 2016) have shown how language models of low resourced languages do not perform as well as language models on high resourced languages.

The first research conducted on Prof Pi in non-English languages was done in conjunction with Ibn Sina University in Khartoum, Sudan (Butgereit, Martinus, and Muna Mahmoud 2023). This involved university students who conversed with Prof Pi in Arabic language. The reader is referred to the previous published paper for exact results but, in general, the students found it easy to converse in Arabic about university level mathematics with Prof Pi. A sample conversation in Arabic with Prof Pi can be seen in Figure 3.

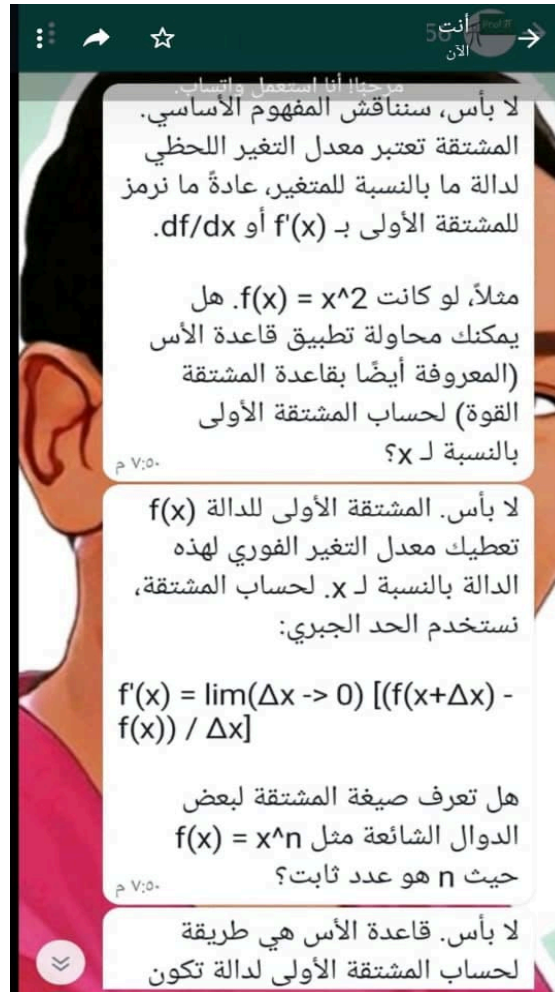


Figure 5: Sample Arabic conversation with Prof

The Arabic Prof Pi project was done with formal ethics approval. Original plans had been to have face-to-face interviews with the students but, unfortunately, violent unrest started in Khartoum during the course of the project (Ibrahim and Siddiqui 2023) forcing universities to close and for many students and university academic staff to leave Khartoum. As a result only questionnaires were obtained from the students.

A subsequent project involved the evaluation using Afrikaans. This was done with a co-researcher who was also a SATI (South African Translator's Institute) registered English/Afrikaans language practitioner. This project specifically looked out possible language errors which Prof Pi made (Butgereit and van Staden 2023). Again the reader is referred to previous published research. One very interesting example, however, is presented in Figure 4.

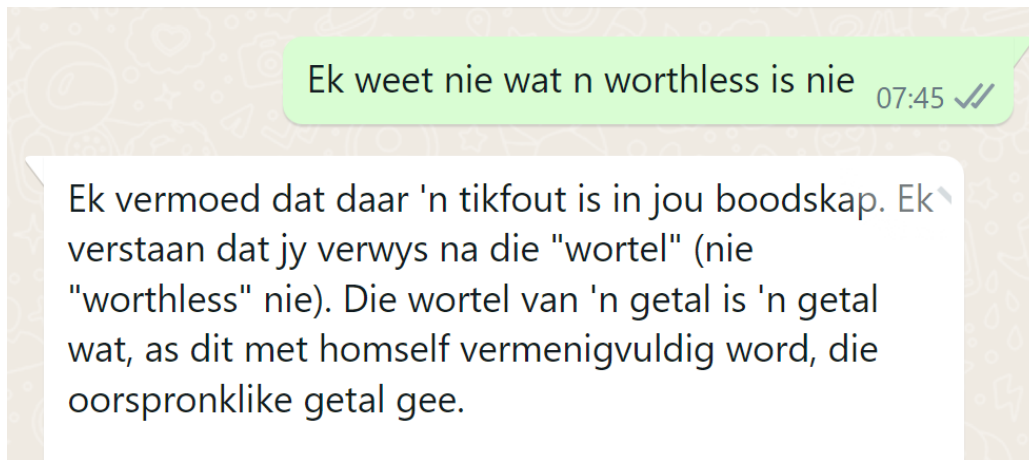


Figure 6: Sample Afrikaans conversation with Prof Pi

In this conversation snippet, the user meant to type “Ek weet nie wat n wortel is nie” (I don’t know what a root is) and the cell phone spelling corrector changed the Afrikaans word *wortel* to the English word *worthless*. GPT-4 responded by suspecting that the user had made a typing mistake and answered the intended question properly.

Additional on-going research is being done in Kiswahili and in Amharic.

The remaining part of this paper specifically deals with Prof Pi operating in Zulu.

Methodology

In order to evaluate Prof Pi using the Zulu language, a Zulu expert needed to be involved. The South African Translators’ Institute was contacted. According to their website, the South African Translators’ Institute is a professional association for language professionals including translators, interpreters, editors, proofreaders, terminologists, content writers, and linguists (SATI n.d.). A request was made for a Zulu translator who was also involved in mathematics education at either the primary, secondary, or tertiary level.

A translator was obtained (and is listed in the acknowledgements) who had post graduate certificates in Education and language specialising in both English and Zulu. The translator was comfortable using mathematics terms and expressions at the primary and secondary school level. The translator was also digitally literate and could use Whatsapp comfortably.

The instructions given to the translator were to hold a brief conversation with Prof Pi in English about a specific mathematics topic and then to hold the same conversation with Prof Pi in Zulu. The translator must then make an informed comparison of the two conversations. In addition, the translator was specifically asked to experiment with Zulu slang and with words that would be considered misspelled in Zulu.

The translator used Prof Pi in English and Zulu over a period of 8 hours and then wrote up a report about the language usage.

Ethics

The research described in this paper does not involve any human subjects. The author hired a qualified Zulu translator who was an adult over the age of 18 (listed in the Acknowledgements) to assist in the evaluation of Prof Pi operating in Zulu language. Since there were no human subjects, no ethics approvals were required.

Results

The translator did put Prof Pi through its paces. For example, one conversation snippet on solving a quadratic equation can be seen below. The original conversation was conducted in Zulu and was later translated by chatGPT into English to be included in this paper for the convenience of the reader.

Zulu	English
User - 2023-05-30 09:19:24	User - 2023-05-30 09:19:24
Ngicela Isixazulula salana: $10x^2 - 162x + 64 = 0$	Please solve this for me: $10x^2 - 162x + 64 = 0$
Assistant - 2023-05-30 09:20:14	Assistant - 2023-05-30 09:20:14
Lokhu kuyisibonelo sokuqala sokuqoqa amathemu amabili. Ake siqale ngokukhipha inani elincane elingaphansi kwamabili amathemu, okuyi-GCD (igesi elincane elingaphansi kwamabili amathemu) ye-10, -162, kanye ne-64.	This is a classic quadratic equation. Let's start by taking out the greatest common divisor (GCD) of 10, -162, and 64.
Ungasebenzisa kanjani i-GCD ukukhipha inani elincane elingaphansi kwamabili amathemu?	How can you use the GCD to factor out the smallest possible value?
User - 2023-05-30 09:38:09	User - 2023-05-30 09:38:09
$5x^2 - 81x + 32 = 0$	$5x^2 - 81x + 32 = 0$
Assistant - 2023-05-30 09:39:00	Assistant - 2023-05-30 09:39:00
Kahle kahle! Manje, sibheke ukuthi singayahlukanisa kanjani le quadratic equation. Isixazululo esijwayelekile sokuhlukanisa i-quadratic equation kuyi-factoring.	Good job! Now, let's see how we can factorize this quadratic equation. The standard solution for factorizing a quadratic equation is factoring.
Hlukanisa le quadratic equation: $(ax + b)(cx + d) = 5x^2 - 81x + 32$. Lapha, $a*c = 5$ (okuyisibonelo lesi-1) kanye nob*d = 32 (okuyisibonelo lesi-2).	Factorize this quadratic equation: $(ax + b)(cx + d) = 5x^2 - 81x + 32$. Here, $a*c = 5$ (equation 1) and $b*d = 32$ (equation 2).
Ngabe ungathola amanani a, b, c, kanye ne-d ukuthi abe nezibonelo eziyisisekelo?	Can you find the numbers a, b, c, and d that satisfy these fundamental equations?
User - 2023-05-30 09:41:03	User - 2023-05-30 09:41:03
a= 5	a = 5
Assistant - 2023-05-30 09:41:26	

Kahle kahle, $a = 5$. Manje sifuna ukwazi amanani b , c , kanye ne- d ukuthi abe nezibonelo eziyisisekelo, njengoba $a*c = 5$ kanye nob $*d = 32$.

Ngicela uzame ukuthola amanani b , c , kanye ne- d .

User - 2023-05-30 09:42:10

$a = 5$
 $b = 81$
 $c = 32$

Assistant - 2023-05-30 09:43:00

Uzame kahle, kodwa b kanye ne- d akucaci. Sizame futhi. Ngokuba $a*c = 5$ kanye nob $*d = 32$, amanani a , b , c , kanye ne- d kufanele ahlangebezane kanjena:

$$(ax + b)(cx + d) = 5x^2 - 81x + 32$$

Siyakwazi ukuthi $a = 5$ kanye ne- $c = 1$ (ngoba $5*1 = 5$). Manje sifuna ukuthola amanani b kanye ne- d ngokusebenzisa ubuholi $b*d = 32$.

Ngabe ungathola amanani b kanye ne- d ?

User - 2023-05-30 09:44:37

Yebo

Assistant - 2023-05-30 09:41:26

Good job, $a = 5$. Now we need to find the numbers b , c , and d that satisfy the basic equations, such as $a*c = 5$ and $b*d = 32$.

Please try to find the numbers b , c , and d .

User - 2023-05-30 09:42:10

$a = 5$
 $b = 81$
 $c = 32$

Assistant - 2023-05-30 09:43:00

You're trying well, but b and d are not clear. Let's try again. Because $a*c = 5$ and $b*d = 32$, the numbers a , b , c , and d should coincide like this:

$$(ax + b)(cx + d) = 5x^2 - 81x + 32$$

We know that $a = 5$ and $c = 1$ (because $5*1 = 5$). Now we need to find the numbers b and d using the product $b*d = 32$.

Can you find the numbers b and d ?

User - 2023-05-30 09:44:37

Yes.

This conversation is also a good example of how Prof Pi spans the first and second paradigms as described by (Ouyang and Jiao 2021).

The translator's report pointed out some linguistic errors which Prof Pi made in Zulu. An example can be seen in Figure 5.

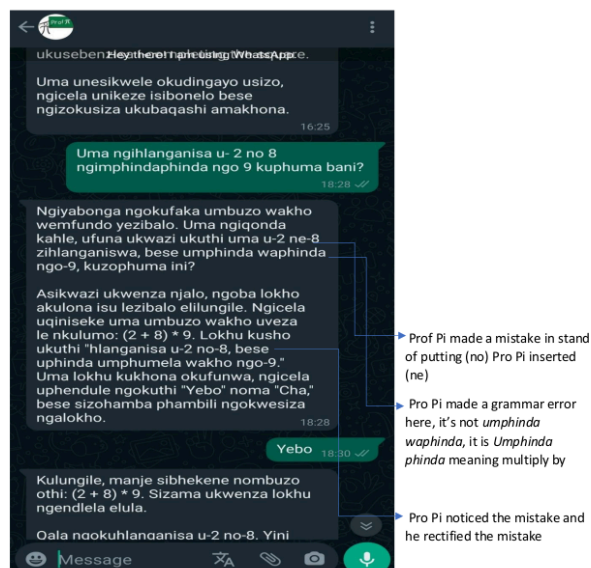


Figure 7: Sample Zulu conversation with translator's comments

The translator found a number of repeatable errors

1. Learners should not write out the Zulu words for the numbers but should use the actual numerical digits instead.
2. Learners should not use slang. Many slang words were not recognized or were misunderstood by Prof Pi.
3. Learners should attempt to spell words correctly.

Despite finding some grammatical errors, the translator's summary was quite positive. The overall conclusion was "Despite having some linguistic errors. Prof Pi can still assist home language Zulu speaking pupils in mathematics."

Unexpectedly, the translator also found that adults who were learning Zulu as a second language could get practical conversational help with Prof Pi even though they weren't interested in learning mathematics.

Conclusion

Prof Pi is an artificially intelligent mathematics tutoring bot which allows learners to access it using the popular Whatsapp cell phone app. Prof Pi is powered by GPT-4 which consumes and generates all of the questions and answers between the learners and Prof Pi. Previous research had investigated the use of Prof Pi in a number of non-English languages including Arabic, and Afrikaans. On-going research is being conducted in Kiswahili and Amharic. This research specifically looked at using Prof Pi in the Zulu language.

A professional Zulu translator was employed to actually evaluate the Zulu generated by Prof Pi and GPT-4. The Zulu translator did find that Prof Pi and GPT-4 did make a number of repeatable linguistic errors especially with respect to spelling out numerical values, using slang, and misspelling words. However, the Zulu translator's final conclusions were extremely positive. Despite making some linguistic errors, Prof Pi could still help home language Zulu speakers with their mathematics.

The use of mother tongue education in Africa has been, and often still is, controversial (Kioko et al. 2014). This paper does not come down on either side of that argument. However, if educational experts believe that mother tongue education is effective, then Prof Pi will step up to help.

Acknowledgements

This research was done in collaboration with Herman Martinus from Deep Tutor, the creator of the Prof Pi platform. Deep Tutor focuses on the integration of artificial intelligence and education to create innovative learning experiences. They have developed a suite of AI-driven products that cater to diverse educational needs.

The Zulu translations were done by Phakamile Ngema, a member of the South African Translator's Institute. She holds post-graduate qualifications in Education with an emphasis on English and Zulu.

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The students' and lecturers' experiences in the use of GIT in IT courses in a HEI

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Abstract

Git is an open-source Distributed Version Control System (DVCS) that assist in tracking changes in code over time and helps to store and manage coding project. Hands-on labs on using Git are done as part of the Programming module by the lecturers and the students use it in the IT courses in the Higher Education Institution in South Africa. In this paper, we explore students' and lecturers' experiences in the use of Git in the Information Technology (IT) course in a HEI in South Africa. We conducted online focus group interviews with a small group of students and also with the lecturers via Microsoft Teams in a moderated setting to explore their experiences in the use of Git in IT courses. The participants were first year and second year students in the Faculty of ICT who use Git and the other participants were their lecturers. Purposive sampling was used to focus in-depth on a relatively small sample. We used inductive thematic analysis to get their opinions, values, and experiences from the qualitative data – the interview transcript. Coding helped to analyse qualitative data and identify themes and the relationship between them. The themes that emerged based on student interview data were as follows: programming language used in the HEI and the first-time experience, ease of use of Git, familiarity with other platforms, and the capacity of the learners to use GitHub and their experiences for project submission. The themes based on data analysis (lecturer interview data) were familiarity with Git and other programming languages, how lecturers marked the student submissions through GitHub and provided feedback, and how they used GitHub in their lectures in the programming module. There are challenges in using Git, especially for unrelated projects, but for related projects, it is fine as it tracks the state of the tree in every single commit made. Some of the pros of using Git are that it includes the social networking aspect and it is quick to start a new repository.

Keywords: GIT in Information Technology courses, lecturer experiences in using GIT, students' experiences in using GIT, Distributed version control system

Introduction

Git (GitHub, 2023), a distributed Version Control System (VCS) that is free and open source, is widely used by many developers in software projects. It “distributes” every version it has recorded for the project. It allows multiple people to work on a project and each person has a complete copy of the repository and the complete history of the tree. VCS is popular in the software industry and higher educational institutions. Some of the basic Git operations are creating a repository, tracking changes, staging and committing the changes made, and viewing these.

GitHub co-pilot (GitHub, 2023; Malinka et al., 2023) is a programming assistant that uses OpenAI's GPT-4 language model and is sometimes vulnerable to attack. Co-pilot can be configured in the Settings page of GitHub's account, and it is dubbed as “your AI pair programmer” (Michel, 2023). A ChatGPT-powered programming tool, GP tutor-

related work is presented by Chen et al. (2023). Hands-on labs on using Git are done as part of the IT modules by the lecturers in some of the Higher Education Institutions (HEIs) in South Africa.

The Technology Adoption Model (TAM) where the technology acceptance perceptions —ease of use and usefulness were focussed (Davis, 1989; Venkatesh, 2000) in this paper. We explore students' and lecturers' experiences in the use of Git in the IT course in a HEI in South Africa. In the next section, we explore the use of Git in HEI for teaching and learning, it is followed by the research methodology, reflections and data analysis, discussions, and the conclusion.

The use of Git in Higher Education Institutions (HEIs) for teaching and learning

GitHub provides sophisticated collaboration and communication tools for students and teaching staff (Glassey, 2019). It has been used as a teaching tool for programming courses lately in HEIs, specifically for managing assignments (Angulo, 2019). The basic commands that are used in teaching and learning are git clone, git add, git commit, and git checkout.

The lessons learned while using GitHub in the classroom are presented in (Tu et al., 2022), and how to employ Git in the classroom is elaborated by Kelleher (2014). A smart model for the categorization of GitHub Repositories is presented in other experts' papers (Aslam et al., 2023). From the student's point of view, GitHub cloud services are effective for implementing a programming training project (Glazunova et al., 2021) and GitHub is a good teaching tool for programming courses (Angulo, 2018). Feliciano et al., (2016) in their paper present the student experiences in using GitHub in Software Engineering courses.

Research methodology

The target participants for this Git study were 1st year and 2nd year Bachelor of Computer Applications students in a HEI in South Africa and the other participants were their lecturers. All the participants signed a consent form and we ensured all their personal information remained anonymous. The questions used for the focus groups are provided in Annexure A. Focus groups allow 6 or more participants (Gaižauskaitė, 2012), are used to collect rich information and there were instances where focus groups ranged in size from two to six participants (Rusticus et. al, 2023). The focus groups are a qualitative research technique that uses 'focused interviews,' and relatively small, moderated discussion groups concentrated on a single topic (Easton, 2003).

We conducted online focus group interviews via MS Teams with seven students to explore their experiences in the use of Git in IT courses. The interviews with the four lecturers were conducted via Microsoft Teams in a moderated setting to explore their experiences in the use of Git in teaching IT courses. There are different opinions on the ideal focus group size and special care must be taken to ensure the appropriate configuration of participants, facilitators, length, setting, and so on, to ensure the quality and validity of focus group data (Masadeh, 2012). MS Teams is an efficient method for online focus group interviews and other authors have used it in their research (Kozlova et al., 2021; Chen and Neo, 2019).

In purposive sampling (Etikan et al., 2016) there is a deliberate choice of participants based on the qualities they possess, who will be able to assist with the relevant research.

Purposive sampling was used in this study to focus in-depth on a relatively small sample. **In thematic analysis (Braun and Clarke, 2006) you identify analyse, and report patterns (themes) within data.** We used inductive thematic analysis (Fukamizu et al., 2021) to get their opinions, values, and experiences from the qualitative data – the interview transcript.

Open Coding (Strauss et al., 2004) helped to analyze qualitative data and identify themes, the relationship between them, and concepts embedded during interviews. Online focus group interviews were conducted in June 2023 with students who were willing to communicate their experiences in a reflective manner. Based on the interview transcripts received on 29 June 2023 the themes and relevant reflections are in the next section.

Data analysis and results

The reflections presented here are based on interview transcripts based on the interviews with the students and the lecturers. The themes that emerged were as follows: programming language used in the HEI and the first-time experience, ease of use of Git, familiarity with other platforms, and the capacity of the learners to use GitHub and their experiences for project submission. These were based on interview data based on the focus groups with the Bachelor's degree students at the Higher Education Institution.

The themes based on data analysis (lecturer interview data) were familiarity with Git and other programming languages, how lecturers marked the student submissions through GitHub and provided feedback, and how they used GitHub in their lectures in any module. The student experiences in the use of GIT in IT courses in the HEI are discussed below.

Programming language used at HEI and the students' first-time experiences

Based on the reflections below, Java was the popular language they learned, although they did another scripting language such as HTML. Some even learned Java (NetBeans) programming language beforehand in the Higher certificate course.

One participant said, "*So last year we learned Java*". Another said, "*So we learned Java, but then we also learned more specifically how to use the GUI with Netbeans*". Other participants also indicate they did Java – "*Yeah, simple thing as they said is purely Java language*". "*You know a bit different variations within Java, but overall basically we learn Java*". "*So for first year we also learned Java and mostly like from beginner to more advanced functions of Java*".

Many participants said it was their first time learning Java – "*Oh, I learned Java*". "*Hi Mama also learned Java, so for me personally, it actually was my first time in learning programming*". Another said "*It was first time with Java. I had done a few courses of block coding beforehand*".

The reflections indicate they also learned another scripting language before joining University, HTML and Cascading Style sheet: "*in school days we did HTML so but in very bad*". "*But yeah, so I have done a form of coding before*". "*So before I've learned HTML, CSS and JavaScript and then officially actually uh Java with varsity*". "*It was my first time doing Java in higher certificate*". Some did not have prior knowledge of Java before coming to Varsity. "*That's my first time being open to programming. I did do HTML in high school and I did other courses just I didn't really do Java in detail, but like the surface of it*".

Capacity of the learners to use GitHub and their experiences for project submission

The capacity of the learners to use GitHub and their experiences for the project (Portfolio of Evidence (POE)) submission is demonstrated in the participant feedback below.

“Sorry, I used to get help to submit a part 1/2 and three of my Poe, and I also used it to do unit testing”. “So for me, I was having issues in the first year with GitHub, so I hadn't submitted through GitHub”. Another student said, “I only submitted through VC learn”. “Umm yeah, so I used it to submit and that's pretty much it was only thing I really did is I pushed them committed data to get up. Also used it to submit my POE assignment for Java. just to submit my Java Poe”. The students did encounter problems while submitting through GitHub. “So last year, I think it was for the 1st and maybe the second part is well, I actually wasn't able to submit it completely”.

The reflections below indicate that some students found it difficult to submit via GitHub. *“It gave me some errors, but the last part I was able to successfully submit”. Another said “I wasn't able to submit part one and two, but I was also unable to submit Part 3 because I didn't know how to”. “at the start of definitely it was definitely quite difficult, probably because it was quite new to me, but I think I at the end of the day I did manage to submit on get up”.*

“And then at the start of on the quarter, difficult of course one to I don't think I have pushed it correctly, but for part three, I'm pretty sure it went through”. “I think mine is the same as everyone else pushing part one and two is quite hard, but when I've got two part three, I was able to push it successfully”. “I had not yet used any type of application like GitHub before that no”.

Students' reflections: The ease of use of Git repository

As indicated in the reflections from the students the ease of use of Git repository is discussed below. *“And now, with a bit of practice, it's actually is very easy and simple as long as you don't type in the wrong things”. I find it easy now with the GitHub repository, because I've I've been explained it's been explained to me in a better way.*

Another participant reflected on the use of cheat sheet provided by the lecturer. *“It's definitely easier”. “You know, we got that edits and also lecturers gave us like a CHEAT SHEET for example for the CMD which actually helped me understand it easier and now I can do it easily”. “Yeah, definitely found it much easier than last year due to those Cheat Sheets Tyler mentioned before”. “Definitely easier than last year and also got a better understanding of it, especially this year”. The lecturer “went through it quite regularly to explain hard work. I find it a bit easier now than last year because we didn't understand the areas as well. So now I do understand, but it happens all about”.*

Some students were regularly using GitHub and found it easy to use and used it for Integrated Curriculum Engagement (ICE) tasks and Portfolio of evidence submissions as in the reflections: *“And then I think now I'm finding good, easier cause I've been regularly using it so it's easier now than it was last year. “Uh, yes, I have used ..GitHub repositories for the programming. Classwork to help me with the assignments”.*

“And yeah, I have and from this year we did an example in class and that's how I use it and to submit now. And it's also just to get ideas on my assignments and uh, my projects.

I was using it when it comes to the ice. that we had to do in class and also referencing to my Poe. This year was my ice task, but those are the only ones that I looked at and the cloud and what is it pushing? I think it was part one assignment to GitHub. Part 2, Yeah, to GitHub. And then before that last year, to use any Git repositories”.

One participant used it for testing and the code from Git they adapted into their program as well as indicated in the reflections: *“Personally I have looked at a few GitHub repositories, mostly to. It was for personal testing, but I did use some of the code”. “Is that actually share the information on the Git repository that actually shares and I use code from there all the time to adapt into my own program”.*

Students’ recommendations to change how the course uses GitHub

Based on the reflections below the students recommended changing how the course uses GitHub. The actual name of the IT personnel was excluded in the reflection below and also any actual names of the students during the interview participation are excluded. One participant mentioned submitting tasks via MS Teams and GitHub were preferable just in case they ran into issues with one: *“But personally I preferred when we submitted on both teams and GitHub. I feel like at least that way, if we're running into issues with GitHub, we can still have a chance at submitting all of our code as well”.*

They wanted a better understanding and introduction to Git early as we see in the reflections: *“Yeah, it should have been introduced earlier in, like dedicated a few lessons to just getting the initial phases of like what it is and how we can use it better and better, better understanding. If it was, yeah, if it was taught large here, like it was taught this year, I think personally I would have gotten much easier and I would have felt more comfortable with it”.*

The students struggled with submitting via Git as in the reflection: *“sometimes we do struggle with GitHub when we submit, so I would also suggest that if we could submit our code on teams as well. From ma'am, I think it would also be helpful if like the same what we did this year as and we .. pushed our ice tasks to GitHub, that we can do the same for first year where you so that you cannot continuously be pushing code”.*

Providing simple Git commands in the form of cheat sheet was recommended. The students recommended teaching GitHub early enough, and they used the cheat sheet provided as indicated in the reflections: *“The only suggestion is that possibly teaching GitHub earlier at an earlier stage, so that if there's any issues with actually understanding it, they have the whole semester to figure it out, or at least before the 1st Part 1 submission. And So what I would suggest, ma'am, is that what (IT personnel) did this year, so he actually created a bit of a CHEAT SHEET, which allowed us to follow and it easily explained gift. So it had the simple git commands for CMD”.*

The students’ familiarity with other platforms

The students were familiar with many platforms and they use it for personal use and at the HEI level and the popular ones they used were – Dropbox, iCloud and Google Drive as per the reflections: *“I'm quite familiar with one drive, Dropbox and Google Drive”.*

“I'm familiar with all three the Dropbox up and Google Drive and that, but I'm more familiar with the Google Drive as I use that in metric to submit my work and save it all”.

“Umm, I'm quite familiar with, you know, OneDrive, Dropbox and Google. If our cloud counts as one as well, because that's where you store data to a cloud”.

"I use them quite frequently for personal use and for schools. So yeah, I'm pretty familiar with those as well. I've used and Google Drive and our cloud. I'm familiar with OneDrive, Google Cloud and iCloud". "The Dropbox and iCloud. I'm familiar with Dropbox, OneDrive and iCloud"

The lecturer experiences in the use of GIT in IT courses in the HEI is discussed below.

The lecturers' familiarity with Git (version control) and programming languages

The lecturers interviewed were teaching Java and C# as in the reflections below"

"I'm teaching Java and C sharp". "Fascinated some like, I don't know, each in C sharp". "No, it's not the first time". "Is not the first time I did teacher making the previous institution"

Based on the reflections, the lecturers started using Git from the year 2022 and they were getting accustomed to it. *"But since last year, so ever since last year have been using it, I'm just trying to get to know most of the comments on GitHub". "So yeah, I've just discovered GitHub since last year myself"*

"I also started using GitHub last year, but in the industry". "But the commands are also the same so, but in terms of the GitHub I started using it with the students here on campus."

Another reflection indicates, "And no, only started last year, so I don't know if my mind somebody response will be but only myself only started using Git last year, so not there any other". "I think there's version control on. Used Dev OPS as well, so it's GitHub and DevOps I'm talking to you now"

Some had a GitHub account before they even joined the institution.

No, I did not have a GitHub account right.

"I did have". Another indicated, "I actually do have a personal Git account and the one that I use umm for the institution as well"

Experiences of the lecturers on the use of GitHub

This section has the reflections of the lecturers on how they trained the students to submit summative and formative assessments via Github: *"I think introduced GitHub to students. When we're doing ICE activities or classic activities, I will also use GitHub during the submissions of the formative and summative assessments"*

"Yes, so similar here". "I've used GitHub to run exercises in class where student can submit the exercise on GitHub and also they are summative and formative assessments". "They submit them on GitHub"

The lecturers were in fact given training to use GitHub as in the reflections below:

"Umm yes, we did have am training which introduced us to basic GitHub commands.

"Yes, we did have training last year"

"Yes, we did have training to introduce GitHub and how we can use it with student or use it in class"

"So yes, we did have training"

The lecturers' experiences in marking project submissions through GitHub and how they gave feedback

The lecturers indicated the feedback on GitHub is one of the features they used the most. *"We able to access students work based on submissions through GitHub". "Umm, actually yes I did".*

"And there's also a feature that I liked. Umm, there's a feature called feedback on GitHub is one of the features that I used most when I was providing or making the what is called the classic activities or ICE activities".

"Yeah, they do submit on GitHub, but when I when I provide feedback I will just provide feedback during the session, not necessarily through IT hub". "So I've been used any of the features that can provide feedback or do grading".

Easy of use of Git repository and other platforms by the lecturers

The ease of use of Git repository and other platforms are in the reflections below:

"Oh yes, it is actually easy to use the Git repository also like the fact that you can even control all, be that mean on the repository. So it is very easy to manipulate the repository basically".

"Yes, I do find it easy to use the Git repository, especially the one where the party Git classroom", "you can be the administrator of the of the repository and take control so it is fairly easy to use".

The lecturers were also familiar with other platforms such as Dropbox, Google Drive, OneDrive, Bitbucket as in the reflections: *"Yes, I am familiar with other platforms that can be used for version control. So basically all of the platforms that you mentioned, umm yeah, I am familiar with".*

"Yes, I am familiar with the platforms that you have mentioned that I saw of OneDrive".

Lecturer reflections: Changes required in IT courses that do submissions through GitHub
Some changes were recommended by the lecturers for the IT courses that do submissions through GitHub. As the lecturers reflected it would be a good idea *"to formalize the use of GitHub to students, I think it was gonna basically motivate most of them to rely basically on submitting on GitHub and familiarizing them themselves with the commands that I used for GitHub".*

The other reflections indicate the need for formalizing the platform. *"Yes, I think it's a case of formalizing the platform and also for modules". "That way, students do group work". "So if they can introduce maybe a formal documentation that is used to align the students with GitHub, that will be perfect actually". "I think they it can be intensified that, you know, students work in a group and use this version control to do their work. And yeah, I think it's a case of formalizing the platform".*

Discussions

The online focus group study elucidates the potential of Git in IT courses in a Higher Education Institution in South Africa. It provides an understanding of the reflections on the programming languages used in the HEI by the learners and familiarity with Git, the lecturers' familiarity with Git and other programming languages. Based on lecturer

reflections the themes were familiarity with Git and other programming languages, how lecturers marked the student submissions through GitHub and provided feedback, and how they used GitHub in their lectures in the programming module. Other themes were the students' familiarity with other platforms the capacity of the learners to use GitHub and their experiences with using Git in task/project submission.

The lecturer (participant) was familiar with Dropbox, Google Drive, OneDrive, Bitbucket as well. The reflections below indicate the learners' knowledge of programming languages:

“learned Java, but then we also learned more specific to.. how to use the GUI with Netbeans”. *“for the first year we also learned Java and mostly like from beginner to more advanced functions of Java”*. Another participant reflection indicated they had knowledge of scripting language, *“I’ve learned HTML, CSS and JavaScript and then officially actually uh Java with varsity”*.

The capabilities of Git for the teaching of programming (Michel, 2023) was the case in our study as well, where the learners who were taught how to use Git, used it to submit their Portfolio of Evidence and also assignments and other tasks for (Java) the programming module. Yet another example of the use of GitHub as a teaching tool for programming is evident in another researcher's work (Angulo and Aktunc, 2018). The students were provided training as one participant mentioned, he was *“provided with any training for GitHub”*. Another student participant's reflection indicates Git as an effective tool - *“actually share the information on the Git repository that shares and I use code from there all the time to adapt into my own program”*.

When it comes to project submission one participant's reflection indicated *“I wasn't able to submit part one and two, but I was also unable to submit Part 3 because I didn't know how to. At the start of definitely it was definitely quite difficult, probably because it was quite new to me, but I think I at the end of the day I did manage to submit on get up”*.

From the lecturer's side, there will be problems judging which student submission is the final one. Based on the lecturer's reflection in this study, the students were able to submit formative and summative assessments via GitHub and they were able to mark it from there. This is evident in another study, GitHub contributes to student learning and helps lecturers provide feedback on assignments and project work (Feliciano, 2016). The participant reflection indicates the lecturer in the HEI, actually created a cheat sheet with simple Git commands, another example of such a cheat sheet is in Git cheat sheet (2023). Based on the lecturer's reflection, there is a *“feature called feedback on GitHub is one of the features that I used most when I was providing or making the what is called the classic activities or ICE activities”*. Another participant mentioned, *“You can be the administrator of the repository and take control so it is fairly easy to use”*.

Conclusion

Through online focus groups, we explored students' and lecturers' experiences in the use of Git in the Information Technology (IT) course in a HEI in South Africa. Some of the main themes based on data analysis based on the student interview data were, the programming language used in the HEI and the students' first-time experience, ease of use of Git, the familiarity with other platforms, and the capacity of the learners to use GitHub and their experiences for project submission. The themes based on data analysis

(lecturer interview data) were how lecturers marked the student submissions through GitHub, and how they used GitHub in their lectures in any module. Our study points to the necessity of Git in IT courses in HEIs for teaching and learning. Both lecturers and the students were familiar with Java. They submitted projects or assignments through GitHub. The results show students are also familiar with Dropbox, OneDrive, and iCloud.

The student participants mentioned it is a matter of familiarising with the Git platform and the students' also felt Git is easy to use. The majority of the participants had a Git account. The participant reflection indicated they could submit assignments on both MS Teams and GitHub in case they ran into issues submitting in one. The basic Git operations usually used in HEI are creating a repository, tracking changes, staging and committing the changes made, and viewing. The lecturers also felt GitHub was easy to use and they could use feedback features on GitHub.

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The students' experiences of using cloud technologies in a HEI during Covid-19 lockdown

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Abstract

The use of cloud technologies became more effective for online teaching and learning in South African Universities during the COVID-19 lockdown period, but later its use became a norm for some modules due to the learning quality it could offer and the ease of use. Google Classroom, Blackboard and Microsoft 365 are the most popular ones used in South African educational institutions for online Teaching and Learning. The students could access these cloud technologies from home using computers, tablets, or smartphones and there was no travel time required to attend physical lectures. The software used was mainly free-fee basis ones or ones purchased by the Institutions and the majority of the module notes or course material was provided via MS Teams, Blackboard, or Google Classroom. During the lockdown period, the majority of the assessments were done online. In this qualitative study, online focus group interviews via Microsoft Teams were conducted to explore the first and second-year students' experiences of using cloud technologies in a South African Higher Education Institution (HEI) during the Covid-19 lockdown. Convenience sampling was used as the above-mentioned participants were around in the HEI for the interviews. We used inductive thematic analysis and coding to analyse qualitative data, to identify themes and the relationship between them. The themes that emerged are discussed in detail in the paper, but the main ones are cloud technologies used by learners in Higher Education Institutions, the benefits of using MS Teams and other cloud technologies during the Covid-19 lockdown for teaching or learning, ease of use of MS 365 and MS Azure and the future of teaching using MS Teams and Azure. The students felt these technologies were used due to the stricter lockdown circumstances and they used them, they fully enjoyed the ability to use the cloud technology to go back and read lecturers' resources and access various resources. The students found MS 365 easy to use but with MS Azure they were finding it hard to navigate and also to publish.

Keywords: Cloud technologies, students' experiences of using cloud technologies, Microsoft 365, e-learning

Introduction

South African students face various challenges such as economic disparities, infrastructure deficiencies, limited access to educational resources, and a shortage of skilled instructors (Oluwatoyin, 2023). During Covid-19 lockdown there was a surge in the use of cloud technologies due to the learning quality it could offer and the ease of use.

Google Classroom, Blackboard (Blackboard, 2021), and Microsoft 365 (Microsoft, 2021) are some of the popular cloud technologies used in South African Higher Education Institutions for remote Teaching and Learning. The video conferencing tools in Zoom

and Microsoft Teams are used by many organizations (Jenkins et al., 2021) and it is even popular in educational institutions.

Cloud computing resources are accessible on demand, it uses remote servers and maintains shared documents, files, software, knowledge, and applications through a cloud-based service (Jenny, 2017). Some of the cloud technologies used for e-learning are online learning platforms, virtual classrooms, cloud-based collaboration tools, cloud storage, and cloud-based learning management systems (Rajabova, 2023).

MS Teams is an effective cloud platform that allows interactive tasks such as email communication, class notebooks, calendars, and assignment submission (Albaaly, 2023). MS Teams can be accessed through an institutional account with Office 365. MS Teams helps to focus on online classes, it is a collaboration area, and it continues to ride the remote work environment (Almutairi et al., 2023). There are challenges in the use of cloud technologies and online learning. Paudyal et al. (2021) in their paper explain how the students interpret the opportunities and challenges of online mode of learning.

As stated in their paper (Schyff et al., 2014) based on perceptions of IT professionals in South African Universities, cloud adoption requires specialized staff and it is important to engage with prospective users for cloud adoption during the planning process. This paper adopted a theoretical model - the Technology Adoption Model (TAM) where the technology acceptance perceptions —ease of use and usefulness were focused (Davis, 1989; Venkatesh, 2000). In yet another teacher acceptance study (Utami et al., 2022) towards cloud-based learning technology in Covid-19 pandemic era, the authors suggest that in TAM-related research all factors affecting the use of cloud-based learning technologies and be implemented for various settings and contexts.

The advantages of using cloud technologies are that it can be accessed from home using computers, tablets, or smartphones and there is no travel time required to attend physical lectures, but online classes. In this paper, we explore students' experiences in using cloud technologies during Covid-19 lockdown in a HEI in South Africa. In the next section, we explore the use of cloud technologies in HEI for teaching and learning, it is followed by the research methodology, reflections and data analysis, discussions, and conclusion.

The use of cloud technologies in Higher Education Institutions (HEIs) for teaching and learning during the Covid-19 lockdown

During the Covid-19 lockdown (coronavirus pandemic lockdown) period, the lecturers and the learners saw the acceleration and the use of various cloud technologies by HEIs in innovative ways. WhatsApp Messenger was used for remote learning in historically disadvantaged schools in South Africa when learners could not attend classes, access recorded tutelage, acquire learning material and liaise with educators (Nkambule et al., 2023). Sathishkumar et al. (2020) give an overview of learning during the lockdown of the Covid-19 Pandemic.

The students improvised their academic areas during the Covid-19 lockdown, for example used the living room, bedroom, etc., for learning but, virtual education happened in an area that the student did not share with others while studying (Zamora-Antuñano et al., 2021). The students did not have any other choice, there was only an online mode of

learning, and cloud technologies played a big role in teaching and learning during the peak pandemic lockdown.

In (Mahmud and Wong, 2023) the authors state MS Teams is a sustainable pedagogical tool. MS Teams was used to improve the speaking ability of High School students (Almutairi et al., 2023), and it became an effective tool to interact with the students during the lockdown period. WhatsApp Messenger was also used in many educational institutions in South Africa and abroad. Nkambule (2023) provides an educator's perspective on the use of WhatsApp messenger as a supplementary tool for school curriculum knowledge transfer and acquisition during COVID-19 stricter lockdown. De Souza et al. (2023)'s study indicates even for physical education technological tools were used. Hamutoğlu (2022) suggests the integration of cloud computing technologies with collaborative learning activities. In summary, cloud technologies were used effectively for teaching and learning during the peak Covid-19 lockdown period.

Research methodology

The participants for this study were 1st year and 2nd year Bachelor of Computer Applications students in a Higher Education Institution in South Africa. The participants in this study signed a consent form and we assured their personal information remains anonymous. Focus groups allow for collecting rich information from 6 or more participants (Gaižauskaitė, 2012) and there were instances where focus groups ranged in size from two to six participants (Rusticus et al, 2023). Focus groups, a qualitative research technique evolved from 'focused interviews,' relatively small, moderated discussion groups (Easton, 2003).

Online focus group interviews via MS Teams were conducted with seven students to explore their experiences in the use of cloud technology in IT courses. The facilitator made sure all had a chance to participate and kept the conversation flowing. She set the time and set the ground rules for the focus groups. It was important to ensure the appropriate configuration of participants, length, setting, and so on, to ensure the quality and validity of focus group data as in (Masadeh, 2012).

The interviews were done in a moderated setting to explore their experiences in the use of the cloud in IT courses. The group of participants is guided by a moderator (or group facilitator) who introduces topics for discussion (Mishra, 2016). The facilitator was non-judgemental and set the tone for the focus group session. Moderators can check group dynamics such as reactions, dominance or passivity, potential conflicts, or other unexpected outcomes (Gaižauskaitė, 2012). Some experts have used MS Teams for online focus group interviews in a similar research (Kozlova, et. al., 2021; Chen, and Neo, 2019). There are some disadvantages to using online focus groups such as stress generated by computer use and greater risks associated with dematerialized participation (Poliandri, 2023).

The idea behind using convenience sampling was the ease of accessibility, geographical proximity, availability at a given time, or the willingness of the participants to participate. Convenience sampling was used to focus in-depth on a relatively small sample. We used inductive thematic analysis (Fukamizu et al., 2021) to get their opinions, values, and experiences from the qualitative data – the interview transcript. A good coding scheme relates data to the literature review (Strauss et al., 2004).

Open Coding (Strauss et al., 2004) where you take your textual data and break it into discrete parts, helps to analyze qualitative data and identify themes and the relationship between them. The online focus group interviews were conducted in June 2023 with the learners. Data analysis was based on the data in the above interview transcripts received on 29 June 2023. The themes and relevant reflections are in the next section.

Reflections and data analysis

Based on online focus group interviews, the reflections by the learners are provided in this section. The themes identified were cloud technologies used by the learners in Higher Education Institutions, the benefits of using cloud technologies during the Covid-19 lockdown, the usefulness of MS Teams and other technologies during the Covid-19 lockdown for teaching or learning, ease of use of MS 365 and MS Azure and the future of teaching using MS Teams and Azure. The themes and reflections are provided below.

The benefits of using MS Teams and other cloud technologies during Covid-19 lockdown for teaching and learning

The reflections below indicate the main cloud technologies the learners used, one participant reflected on it: *“we used teams in the first year”*. When one cloud technology was not working they had a choice to use another specially to submit assignments.

Five participants mentioned they used both MSTeams and VCLearn (similar to Blackboard). *“we used teams to submit and also learn to submit so that we had a redundancy for if teams wasn't working”*. Another participant reflected: *“we use Teams as well as we submit on VC learn / Blackboard well and that's the only applications we used”*

The learners' reflections on the use of cloud technologies during the Covid-19 lockdown indicate they used Google Drive and MS Teams and it was to access resources and for their task submissions. (The actual participant name was replaced with participant 1 in the reflection). *“I use Teams and Google Drive”*. *“We also used like Google OneDrive and those kind of things to submit as well”*.

“It wasn't the first time using those cloud, as (participant 1) said, I submitted a lot of things on Google Drive for matric as well as Teams”. *“Definitely utilized Teams a lot for submissions as well as you know the Google Drive to access things and things off to our teachers”*. *“It was kind of the first time for higher education or varsity that I used it for”*. Another participant used it even cloud technology even in grade 12 as in the reflection: *“It was my first time using it in matric”*. *“Maybe it was also my first time using it in higher Institute”*.

The usefulness of MS Teams is also evident in the reflections below: One participant said, *“I think it made it much easier personally, because it didn't matter where you were. You can have teams on your phone or on your computer, so you were able to attend lectures no matter what your circumstance was”*. Another participant mentioned about the ability to have MS Teams on multiple devices: *“I think it's very useful cause you to have Teams on multiple devices, whether it's your phone, your laptop, desktop and it's not specific to those laptops”*. *“So if you have a lesson where you can't come in for coverage reasons, you still can attend classes”*. *“So I definitely think it is a good app to was tool to utilize like”*.

There was one different reflection as well, the participant mentioned finding it hard to learn, due to the stricter lockdown circumstances they used it, but they enjoyed the ability to use the cloud technology to go back and read the resources uploaded by the lecturers. *“Personally, I don't enjoy it. I find it a lot harder to learn”*.

“Over like a laptop and not in person, but definitely from the circumstances”. *“Was a great tool to use to accommodate that”*. *“Uh, according joined it, cause as previous people have said, you can be anywhere and you can still attend what you need to attend”*.

“Also quite like that you could like record and then like go back and read”. *“Yeah, definitely a good tool to use, especially when connecting with lectures and other students”*.

The learners’ reflections indicate MS Teams is a *“good tool to use, especially because you're able to record the lessons and then watch them after like if you don't and if they don't “Understand something and we watch the lesson”*. *“So you're able to continuously go back to understand what you were learning”*.

Ease of use of MS 365

The students indicated MS 365 was easy to use. As indicated in the participant reflection the ease of use of MS 365 during Covid-19 lockdown is elaborated on:

“I did find it quite easy to use, but I had used it in previous instances so I did already have an idea of what I was getting into”. *“I found it very easy because I already had experience previously and since it was such since it's such a widely used platform, I could do a lot of research with it”*. A few more participants mentioned MS 365 was easy to use: *“Uh, yeah, I found it really easy, ma'am”*. *“It was easy to use cause I've used that before”*. *“Yes, ma'am, it was easy”*.

Ease of use of MS Azure

The participants mentioned they had MS Azure account. *“Oh yes, I do have an Azure account”*. The ease of use of MS Azure is clear in the participant feedback below: *“MS Azure was not easy to use”*. *“Umm yeah, some of it is a little bit confusing still”*. *“I still haven't learned the basics are still a little bit confusing, but I'm managing to do what I need to do for the cloud”*.

Some participants’ reflections below while using MS Azure indicate it is difficult to navigate in Azure: *“Yeah, my experience is very poor”*. *“It's very new to me and I'm still trying to grasp what it's about”*. *“I still found it quite difficult. I don't think I've been exposed to it enough, and I definitely need more practice.”* *“I also found it quite difficult to navigate through Azure. And I had no experience before that”*. *“I am struggling with Azure cause it's kind of challenging to navigate but yeah”*. *“I'm with Azure. I'm struggling. It's not as easy as, umm GitHub. It's quite more challenging”*.

The future of teaching using MS Teams and also using Azure

The future of teaching with MS Teams and also with MS Azure is demonstrated in the participant feedback below: *“Remember you learning using Azure and you also have to use MS Teams. So personally I think it's quite exciting again with the option that if you*

weren't able to attend physical classes, you could still attend lectures and understand what's going on and what's recordings back with a zero”.

The participants even compared the future of teaching with various technologies, they felt MS Teams is a better option. Most reflections indicate MS Teams is a great platform. *“I don't think I know enough about Azure to comment whether it could be useful or not. So for myself, personally, I think MS Teams is a great platform to use”.*

“Because I feel like you can get much more easily distracted online as you just, I find that I don't learn a lot because you know, there's no one knows if I'm sitting on my couch or if I'm accessing for learning with Azure, you know, it's that it obviously because it's new and I might use to it”.

“And I really enjoy MS Teams. As everyone said, I think that's great when you can't make lectures or you can't attend lessons and especially really enjoy the recording. I just love to go back and rewatch it and get better understanding and information that I've missed with Azure”. “Teams is a better option for learning and I feel as though as there is quite complex and because I personally, I don't understand what's going on, I don't think it'll be a useful tool to use to teach”. “I think if maybe we understood it, it can be, but Teams is more better than Azure”.

The students still prefer teaching and learning via MS Teams as one more participant reflected they can go back and access recordings: *“So for MS Teams, I think it's a great tool for teaching in the future, especially with being able to access recordings of lectures that you might have missed”.*

“Ma'am, I agree with everyone that Teams is actually a great platform to teach and report, cause a lot of students that aren't able to attend can actually go back to the videos that have been recorded when it comes to Azure”.

The students preferred a proper introduction to MS Azure, as they found it challenging to navigate through Azure. *“I don't know a lot about it and I found it quite difficult in the at the moment, so I can't really comment on that. And also as I said before, with connecting with lectures and students and sharing information on the platform with Azure like I would, I would suggest having a like a proper introduction on it before commencing with that as a teaching platform because it's kind of like I said before, a struggle to navigate through”.*

“It feels a little bit more stressful. I think if we were given a full lecture before we started with them, like with GitHub as well, I think it would be a little bit easier. So Microsoft Teams is very useful because people could can share work with each other with uh through the platform and then Azure”. The participants also found difficulty in publishing with Azure, apart from the difficulty in navigating through it.

“As I also said, it's kind a challenging to navigate and I would prefer if they could like teach the students first on how to use the platform and then proceed to using the actual platform”.

“So for me personally, when we were testing pushing like publishing applications from Visual Studio to Azure, we had a very weird issue where it would say that it would take about 5 minutes to publish, but it never actually published. That issue has since now gone

away, but I'm not sure if it's was an issue with the school and our students accounts because it worked fine for our lecture”.

Discussions

This online focus group study elucidates the student experiences in using cloud technologies in IT courses in a Higher Education Institution in South Africa during Covid-19 lockdown. It provides an understanding of the reflections on how and for what purpose the learners used cloud technologies. Majority of the participants used MSTeams and some used resources in Google Drive link as an alternative.

As one participant said, *“Microsoft Teams is very useful because people could can share work with each other”* and another said *“it is a great platform”*. This is the case in other authors’ paper (Almutairi et al., 2023) where they mention MS Teams is characterized by the ease of use for the teachers and learners, and it enables the students and teachers to gather in one location. As one participant said one *“can have Teams on your phone”*. It is cost-saving and the cloud technologies improve accessibility of resources.

Jenkins et al. (2021) examine the online teaching and learning tools, Microsoft Teams and Blackboard Collaborate Ultra, and how HEIs adapted to use them during Covid-19 pandemic. This is a similar case in our study the participant (during the Covid-19 pandemic) used the cloud technology to *“access recordings”* of the lessons that they missed. Many students agreed they used various cloud technologies for submission, MSTeams and Blackboard in particular, as many participants in this study mentioned the use of *“teams and VCLEARN”* (in the HEI in this study VClearn, similar to Blackboard).

During the Covid-19 lockdown, the students used popular cloud platforms - *“Google Drive to access things and things off to our teachers”* as one participant mentioned, and another participant used both Teams and Google Drive. The participants in this study were struggling with MS Azure, as they were finding it difficult to navigate as one puts it – *“I am struggling with Azure cause it's kind of challenging to navigate”*. Humeniuk and Romaniuk (2023) agree MS Azure is difficult for the average user and you might have to take courses in use beforehand.

Although cloud technologies allow to monitoring of student work online, remote learning and the use of cloud technologies have some disadvantages. A participant reflection indicates *“you can get much more easily distracted online”* and *“no one knows if I'm sitting on my couch or if I'm accessing for learning with Azure”*. During the COVID-19 pandemic, the students could study at a table, in the living room, in the bedroom corner, or the dining room as is evident in other research (Zamora-Antuñano et al., 2021).

Conclusion

Specifically, the study points to the necessity of Cloud technologies in HEIs for teaching and learning. Online focus group interviews were conducted with the learners in the HEI. The reflections of the students who used these technologies during Covid-19 lockdown are presented in this paper.

Some of the themes based on data analysis of the students’ interview data were: cloud technologies used by the learners in Higher Education Institutions, the benefits of using MS Teams and other cloud technologies during Covid-19 lockdown for teaching or

learning, ease of use of MS 365 and MS Azure and the future of teaching using MS Teams and Azure. The reflections indicate, that MS Teams and Microsoft 365 are easier to use, but the students found MS Azure difficult to navigate. Google Drive and Blackboard were used by the learners to access resources posted by the lecturers, especially when the learners missed the lessons.

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The effects of digitalisation on assessing learning outcomes in accounting

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Abstract

The aim of this paper is to reflect on how digitalisation affected the assessing of learning outcomes in an accounting module. This is a reflective commentary based on personal experiences of two accounting academics located in two different higher education institutions (HEIs) in South Africa. The data was collected through observations and document analysis prior to and during Covid-19 pandemic. During the Covid-19 pandemic period assessments had to be conducted digitally using Learning Management Systems (LMS) platforms. This paper found that there were difficulties with upholding integrity of online assessments. Additionally, it was discovered that the available question types on LMSs did not fully accommodate the accounting subject as it often require drawing of tables and marking of step-by-step calculations. These findings have a direct influence on low/high academic performance and assist in improving academic practice by identifying areas of weakness with online testing methods. Online assessment moderation process by external moderators should be improved. This paper gives an insight on how accounting assessments adapted to an online learning environment. The paper recommends that online assessment policies have to be developed or reviewed to establish preventive measures of protecting the integrity of online assessments and promote fair marking.

Keywords: online assessments, question types, assessment integrity, moderation

Introduction

The Covid-19 pandemic disrupted the traditional face-to-face (F2F) classroom learning and teaching and forced allegiance on digital and blended learning via Learning Management Systems (LMSs) platforms such as Blackboard, Moodle etc. Digitalisation of education meant high reliance on LMSs. These online platforms simplified learning and teaching and general administration of students' academic activities. The abruptly migration from F2F learning and teaching to digital learning platforms meant several changes in the education landscape. One of the key areas affected was how assessments were conducted traditionally in a paper-based format with invigilators to non-invigilated online assessment that could be made available to students for periods even longer than 24 hours. Traditional sit-in assessments with printed question papers and answer sheets had to be transformed to be compatible with digital platforms. This transition was not as simple to numeric-based and practical subjects such as accounting.

This paper reflects on how digitalisation has affected the assessing of learning outcomes in accounting. The paper highlights challenges experienced with digital transformation of accounting traditional paper-based assessments in a South African context. Consequently, this paper points the advantages offered by digitalisation of assessments. This is a reflective commentary of two accounting academics from two

higher education institutions (HEIs). This reflection is based on their vivid experiences of moving from F2F invigilated assessments to the unmonitored online assessments using LMS platforms.

Theory of performance

The theory used as the lens for this paper was the Theory of Performance (ToP). This theory is derived from Elger (2007). The word perform was distinguished from the word performer whereby the former is a result, and the latter is an individual or team. According to Elger (2007), there are 6 fundamental components of academic performance namely, knowledge and skills, identity and personal, fixed, mindset, conducive environment, and space for practice. The Covid-19 pandemic caused havoc to academic performance as online learning created a gap in learning as students no longer had structure, wrote open book assessments, and did not have sit-in examinations for the qualifications across the two HEIs. Furthermore, loneliness, anxiety, and depression caused students to lose hope especially as many students could not stay at their residences and found difficulty in studying from home due to poor socio-economic circumstances. Lastly, with being unable to have sit-in tests and exams or study groups, students were unable to work in a practical setting. These factors all contributed to changes in academic performance.

Assessing learning outcomes in accounting

Sound tertiary level student development should contain an element of student feedback regarding the achievement of learning outcomes. Students learning through digitalisation often lacked an online presence and perhaps did not accurately evaluate a module as postulated on ToP. Using LMS resources, making videos and recordings were not desired by all students especially due to data and network availability constraints. These reasons coupled with the fact that students did not behave ethically during online assessments proved difficult for academic facilitators to assess how well learning outcomes were met. During the planning process of a module, it is essential to get student feedback regularly to ensure the syllabus is structured in the most conducive and optimum way.

In accounting, the underpinning structure is identifying and interpreting information to allow users of financial and non-financial data to make decisions. Applying problem solving skills, independent thinking skills an identifying principle using relevant accounting frameworks is essential for all learning outcomes be it in the tax, auditing, managerial accounting, or accounting discipline. With digitalisation, students were unable to hone these skills which caused a gap in knowledge which has transcended from one academic year to another. Topics such as financial statements, general ledgers and the accounting equation were very difficult to test using LMS platforms as all students did not have access to the same technology. Additionally, the design of online assessments was unfamiliar to students especially those who were new in HEI environment.

Online assessments

The eruption of covid-19 pandemic forced academics to move away from pen and paper assessments designs to the online assessments. The accounting academics had to use the question types provided by the LMS platforms. The common question types found in these LMS platforms are multiple choice questions, true or false, essay type questions, matching, fill in blanks, calculated numeric, jumbled sentence etc. Some LMS platforms have lesser question types than others, and that further limits the choice of how to ask questions. Accounting is a numeric-based subject that require drawing of tables and

recording of values. In a sit-in examination accounting students used to be asked to prepare in table format journals, general ledger accounts, financial statements etc. However, none of these platforms accommodates the drawing of tables where students can add descriptions and values. Additionally, writing formulas with fractions and symbols in an online assessment became difficult and sometimes impossible for students as well.

ToP posits that traditional assessments consider students using a thought process of deducting and reasoning. In traditional accounting assessments, when students are required to calculate certain amounts or totals, they would additionally be asked to show workings and calculations for method marking of the steps used to get into an answer. Therefore, on a sit-in accounting assessment the method marking was considered, meaning not only the answer is marked but the calculation steps and procedure followed by students to get to an answer received points. This practice of method marking protected students and ensured fairness of marking accounting assessments, otherwise if only the totals were marked then one mistake would mean students lose marks for the entire question. This posed a challenge in setting online accounting assessments with automated marking.

Accounting examiners had to think deep in how to transform the tables-based questions to fit with the available question types of the LMSs. For example, a multiple-choice question requires a selection of an answer from a list provided, the answer might be a total value that students could get by making long calculations. Giving 5 points for such questions would be fair because getting to the answer was not simple. However, the 5 points becomes unfair if the students miss the total because one of the calculation steps was incorrect. Therefore, marking of the question types on LMSs required thorough moderation to protect students from unfair marking practice.

Other accounting academics used an easy way out by uploading the MS Word or PDF question papers with an answer sheet or template on the LMS platforms. In such instances students are required to download the question paper write the answers and upload them on the computer. Though this method is an easy way out to academics it became difficult to students as they had to have printers with scanners in addition to their computers, laptops or tablets. Additionally, this method of conducting online assessments is highly vulnerable for cheating as students can sit together and collude when writing an assessment in this method. Therefore, this method of assessment compromises the integrity of the assessments.

Assessment integrity

ToP recommends integrity to go hand in hand with success. Elger (2007) pose that the level of identity component of ToP has to do with the maturity and discipline of students in doing the right thing. The invigilation of assessments by appointed assessment officials was one of the key measures ensuring that there are no misconducts happening and ensure that all students finished within the duration of assessments. The assessment integrity is a fixed factor that needs to be protected and never be compromised hence the importance of invigilation. Yong (2021) noted that in New Zealand during the covid-19 pandemic the invigilated examinations were completely replaced by online assessments that were non-invigilated. Digitalisation meant that the assessments can be written anytime, anywhere, and without invigilation. This opened a gap for learners to breach some of the assessment rules and regulations. Ahadiat and Gomaa (2020) add that students get easily tempted to

cheat the online assessments. In addition to plagiarism several uneasily detectable forms of cheating came to existence due to unmonitored online assessments such collusion and contract cheating. According to Morris (2018) contract cheating happens when a student asks a third party to submit or write his or her assessments at a cost or for free. The third parties can be fellow students, friends, tutors, family etc.

Preventive measures need to be developed and considered in the designing stages of assessments. This poked differences and weaknesses of one LMS platform from another as some have limited features than others. To prevent some of the students' misconducts in a digital assessment an academic institution needs to intensify training of staff on how to use these LMS platforms. Some of these preventive measures require students to have compactible devices that are sometimes expensive. For example, the other LMS in one institution have a feature of video recording a student when writing the assessment, and this feature can detect any movement of the student. However, this feature requires that student use laptops with built-in cameras and that makes it difficult to apply it as not all students have such devices.

Guangul, Suhail, Khalit, and Khidhi (2020) confirmed that using tracking features to monitor students' movements while writing often require that they have specialised software and hardware features on their devices. The lack of assessment integrity means that the academic performance is not a reliable indicator of level of achievement regarding the learning outcomes. Therefore, the students' academic performance as a yardstick of measuring attainment learning outcomes becomes unhelpful. The academic performance levels of students are important in demonstrating the quality of teaching and readiness of students for progression. The implication of cheating in assessments is that the real-world in all industries receive graduates that are lacking knowledge and competency. This situation creates a wrong assumption that the graduates have knowledge and are competent to perform duties expected from them by virtue of their qualifications. The education sector yield graduates that lack graduate attributes such as honesty and integrity. Ensuring assessment integrity needed students to have technological resources with specific features.

Resource availability factor

The other critical challenge with the online assessments is the access and availability of resources for students. This exposed students who comes from disadvantage background communities to inequalities. The issue of resources highlighted the context of performance as one of the key components of ToP. Many of the students in both universities in this study originate from disadvantaged background, with some coming from single-parent families or without parents. Although parents of other students are working but they are low-income earners. Government funds the education of these students via a National Student Funding Aid Scheme (NSFAS). The students struggle to afford computers or laptops. Therefore, to expect them to have printers and scanners in addition to computers/laptops became difficult. In some instances, students used their mobile phones to write online assessment. However, that brought other challenges with certain questions becoming very big on the screen and making it difficult to read instructions and answering.

Additionally, some students reside in shacks dwelling in townships where there's congestion and noise. These disadvantaged communities are not conducive for learning. The internet connection is very poor on some locations forcing students to go and search for places with better network connections when they have to write examinations. The network connection relies on the availability of network data or WiFi that are very expensive in the South African context. Electricity availability is another challenge, some of the students come from rural areas or shacks where there is no electricity infrastructure. Even those that reside where there is electricity infrastructure, they battle with the ongoing electricity loadshedding in South Africa. The loadshedding periods run twice or thrice a day and the electricity will be off for 2-to-4-hour slots. This means that the online assessments cannot be conducted at the same time and should be opened for a period not less than 12 hours to ensure that all the students are accommodated. This then compromises the integrity of the examinations as some students know the content of the examination from those who wrote before them. This finding highlights the digital divide, whereby familiarity with digital tools, access to digital resources and educational use of digital tools have been a concern as many students did not possess a sound digital literacy or resources.

Lonely students

The ToP reiterates the isolation of students has an effect on success. The online assessments are a very lonely experience to students. The feeling of being in presence of classmates and know that everyone is feeling the same pressure is motivational on its own. With the online assessments students do not have the opportunity to ask for clarity on questions with unclear instructions or vague. When a device misbehaves and kicks a student out of the system there is no one to ask for technical assistance and it becomes difficult to prove to the lecturer that the student had a technical glitch. The type of device sometimes makes the connection to be slow and takes time to load each question and answer.

The covid-19 pandemic has led to an increase in depression for many people including tertiary education students. According to Arora, Chaudhary, and Singh (2020) anxiety and depression due to covid-19 pandemic and online assessment have contributed immensely on poor academic performance of students and increased dropout rates. As a result, Al-Nasa'h, Awwad, and Ahmad (2021) found that online learning generally increased levels of anxiety and reduced students' satisfaction with online learning.

Due to social distancing, isolation and a lack of interactive activity, students were unable to seek peer support, contact assistance from their lecturers and in some cases were unable to cope with the new normal that Covid-19 brought (Singh et al., 2020). These lonely feelings brought about a lack of confidence and will-power during assessments and tasks affected students' capability and performance (Cavilla, 2017). The students learn from group discussions before and after the F2F assessments and with online assessment such discussions are missing. Peer support is essential in student growth and development. Several factors aid the acquisition of knowledge such as multitasking assignments, group work and practical tutorials in a classroom setting (Strom et al., 2019).

Moderation

The moderation of assessment is a key important quality assurance measure of the assessments process. When designing the online assessments, the assessors must ensure that the marking is as accurate and fair as possible, time allocation is appropriate, and the assessment is aligned to the learning outcomes. The moderation of exit level subject assessment is done by external moderators. Gamage, Pradeep, Najdanovic-Visak, and Gunawardhana (2020) emphasise that external moderators are important in ensuring quality of assessments and institutions should strive to ensure that any weaknesses with their processes are addressed.

With online assessment the challenge is that external moderators needed to be granted access to the university's LMS as the rights were only limited to academic staff employed at a specific university. These external moderators sometimes do not have knowledge and experience of using these LMSs. In some instances, they had to be trained on how to use the university LMSs. The assessors had to develop two forms of assessments to accommodate the external moderators. The first one would be a paper-based question paper and memorandum and then take the same question paper and transform it to be compatible with the LMS. The external moderators sometimes could not detect the mistakes and online challenges that would be experienced by students during the online assessment session.

On the other hand, the system marking online is very strict for example an amount with decimals must have a dot rather than a comma and must be without a currency symbol. If a student committed any of such mistakes, then the system would mark them wrong. Therefore, the LMSs are still lacking in having a seamlessly process that accommodates external moderation of online assessments. Different assessment options were applied by academics without policy guidance. Some assessments will be available for few hours, others whole day or a week. Policy on online assessments should be developed or reviewed to ensure that quality of online assessments is of good standards.

Instant feedback

One of the key advantages of online assessments is the instant availability of results. Alruwais, Wills, and Wald (2018) confirmed that online assessments assisted in quick measurement of lesson outcomes by providing immediate feedback to students. Students seem to enjoy this feature. Dawson (2020) raised that other positives of online assessments according to students' perspective is writing at the comfort of your home saving time and travelling costs while the performance results are immediately available. With traditional assessments, students would write on paper in an examination venue and then wait for several days for their results. With activation of certain features of the LMSs the feedback about the academic achievement of student could be made available immediately after they write an assessment or on a specific date selected by the assessor. This reduced the anxiety of student of having to wait for many days in anticipation for their results.

Additionally, this feature is more valuable for formative assessments where students have an opportunity to re-write an assessment if their results are low. In a traditional pen and paper formative assessments are cumbersome as academics have to re-mark the assessments repeatedly until they are satisfied that learning has occurred. Formative assessments are helpful in promoting deep learning. With online assessments the academics can download a report showing how students performed in each question. This

enables academics to identify the areas where they need to put more emphasis in their curriculum delivery.

Significance of the study and limitations

A study related to how digitalisation of assessments influence academic performance adds to the current body of knowledge as it highlights key areas that require improvements of academic practices. Academic facilitators can use the information provided in this paper regarding assessing learning outcomes in digital platforms to enhance their future curriculum delivery planning. Methods and strategies that did not work, could be adjusted, or simplified and methods that did work, can be amplified. Data was not collected first hand from students or academic facilitators which prevented an accurate reflection and comparison of throughput. Furthermore, this is a qualitative reflection of what transpired in two HEIs therefore generalisation is not possible. Future studies can delve using qualitative and quantitative data collection from students during covid-19.

Conclusion

This paper provides an insight on challenges experienced with online assessments. Assessment integrity, moderation by external people, and resource availability were identified as some of the challenges. Professional development related to LMSs need to be provided for academics to ensure that they know how to use system features that can prevent cheating during assessments. Access to LMSs should be extended to external moderators to enable them to moderate the online assessments on the system. This will assist them to detect what might be challenges of students when writing the online assessment. The appointment of external moderators should include as a minimum requirement the knowledge of LMS. Automated marking and Instant feedback to students has been pointed out as one of the key advantages of online assessments. However, a caution was posed that careful considerations should be made in ensuring that automated system marking is fair and reasonable to students.

Additionally, this paper raised that technology could have technical challenges that can frustrate students. These technical challenges are sometimes beyond the control of students. The emotional effect of online assessments on students has been pointed out to provide an insight to assessors. The academic facilitators should be mindful and considerate in their approach when students request second chances based on technical glitches. Academics need to be thoroughly trained on how to use the LMSs for them to be able to retrieve students lost submissions and get audit trail reports of students' movements in the system. Factors related to how digitalisation of assessment influences the trends of academic performance need to be scrutinised in all angles.

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A scoping review of applying the Delphi method based on how the COVID-19 pandemic impacted conducting research

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Abstract

South Africa and the world had been adversely affected by the Coronavirus pandemic. It became nearly impossible to host face-to-face interviews for data collection as meeting in person increased the risk of infections. It was difficult to gain direct access to conduct research, as companies, schools, and researchers resorted to working virtually. Therefore, the Delphi method was crucial to ensure continuity and progress in the academic world. It is not concerned with demographics and allows the study's outcome to be validated and verified with expert reviews, making it a more suitable method during the COVID-19 pandemic. The purpose of the study is to provide evidence of the use of the Delphi method to add value to research and replace face-to-face interviews based on the impact and restriction of COVID-19 pandemic. The study conducted a scoping review to identify articles that used the Delphi method to reach a consensus due to the COVID-19 restrictions and unavailability of face-to-face interviews with participants. The articles were identified in the Web of Science, Scopus, and IEEE Xplore databases as well as Google search engines. Only five articles out of 89449 publications were found appropriate for the purpose of this paper.

Keywords: COVID-19 pandemic, Delphi method, conducting research

Introduction

The first case of COVID-19 emerged in Wuhan, China, in December 2019 (Wu, Zhao, Yu, Chen, Wang, Song, Hu, Tao, Tian, and Pei, 2020). The virus was spreading so rapidly and causing high mortality and morbidity rates that the World Health Organization (WHO) declared a global pandemic on March 11, 2020 (WHO, 2020). In the wake of the COVID-19 outbreak, most countries in the world faced a lockdown. South Africa, for example, quickly responded by imposing a strict lockdown and announcing a plan based on an "alert level" approach. In five stages, this plan gradually reopened the economy and social life for the subsequent months (Stiegler and Bouchard, 2020). In addition, a global public health campaign was launched in the absence of a cure to prevent the spread of the virus by encouraging physical distancing, frequent handwashing, following respiratory hygiene, seeking medical care early, avoiding face touching, and following advice given by health authorities (Khan, 2020).

There have been serious setbacks in every area of life, and the academic world was no exception. van Schalkwyk (2021) notes that the lockdown impacted academic research in cases where they were dependent on laboratory work or planned to conduct clinical trials or field research, thereby delaying or redesigning research where possible. This forced academics to rethink their purpose and methodology to lead the resumption of their academic, research, and development activities as many qualitative research techniques such as observation, interviews, focus group discussions, and community studies require direct personal interaction with people which have become unviable because of the COVID-19 pandemic (Rajhans, Rege, Memon, and Shinde, 2020). This study advocates the Delphi Method as a research approach/strategy for conducting qualitative and quantitative research. A method that primarily involves collecting data without face-to-face contact. The rest of the study is structured as follows: the methodology, followed by the literature review, the discussion of the results and finally the conclusion.

Methodology

Scoping reviews provide a comprehensive overview of a broad topic (Colquhoun, Levac, O'Brien, Straus, Tricco, Perrier, Kastner, and Moher, 2014; Peterson, Pearce, Ferguson, and Langford, 2016). It is an information overview that aims to address exploratory research rather than a systematic review that answers specific questions (Peterson et al., 2016). In a scoping review, definitions are often clarified using different methodologies, which is not the case with a systematic review (Munn, Peters, Stern, Tufanaru, McArthur, and Aromataris, 2018). This paper conducted a scoping review to examine the application of the Delphi method by various scholars to achieve a specific goal. In identifying relevant sources for the research topic, the following databases were used: Web of Science, IEEE Xplore, and ScienceDirect using the search terms "Delphi method", and "application of the Delphi method due to COVID-19". In addition, the Google search engine was utilised to manually search for other publications on the web that included discussions on the Delphi methods. The search range was from 2020 – 2021 and was undertaken in September 2021. The database search identified 89385 relevant articles describing the Delphi method. As a result of the screening process, 29817 eligible articles were identified. Fifty-nine thousand six hundred thirty-two records were excluded based on foreign language, abstract and citation ranking. Furthermore, 29812 records were excluded based on the focus of the article and duplicated articles. As a result, only five were deemed eligible for the study (see Figure 1).

Seven (7) supervisors and co-supervisors for Masters and Doctoral students, with more than 10 years of experience, from five South African universities were selected by convenience and through purposeful sampling. This was to find out if their students were impacted by the effects of the COVID-19 pandemic in completing their degrees. For the qualitative data collection, an excel spreadsheet was used to document the data from the interviews and was analyzed subjectively to determine what were the emanating themes from these interviews. Based on the themes identified, they were linked with descriptive statistics in the figures and the interview feedback was provided with inverted commas which was then linked to the literature and the findings.

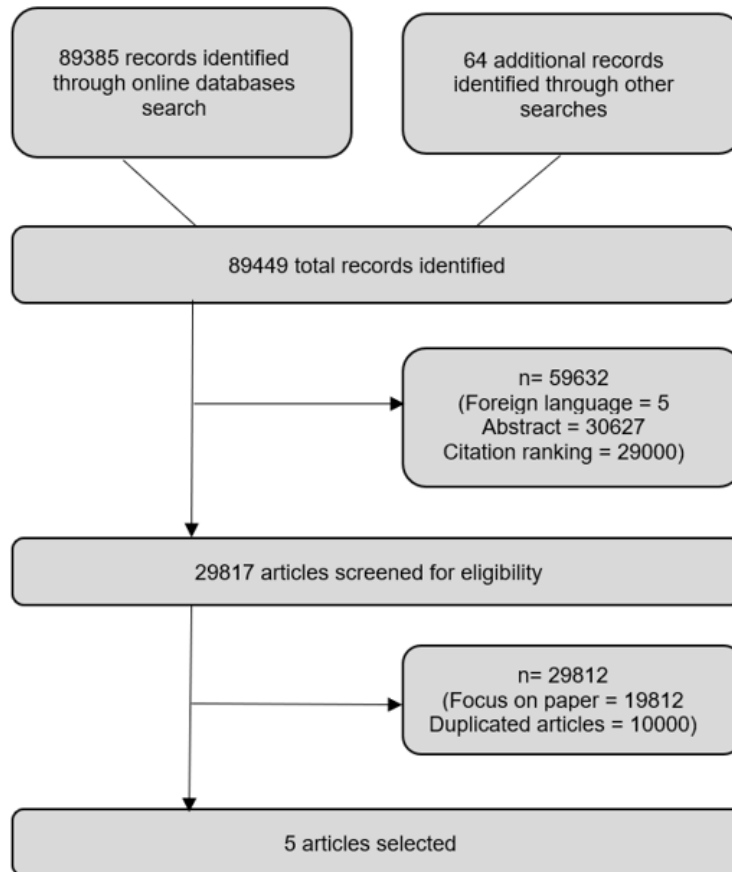


Figure 8: Record Selection Process Flow Diagram as adapted from (Moher, Liberati, Tetzlaff, Altman, and Group, 2010)

Literature Review

COVID-19 has globally impacted societies, economies and health, education, and politics (Hamrouni, Sharif, Sharif, Hassanein, and Abduelkarem, 2022). Research methods were discouraged, especially when it came to data collection. Consequently, researchers faced challenges and new opportunities. Teti, Schatz, and Liebenberg (2020) describes the pandemic as an event that disrupts social order. Many studies exploring education and digital learning rely on a few traditional study formats such as large-scale surveys, semi-structured interviews, focus group discussions, and questionnaires (Lupton, 2021). At the same time, social distancing measures and public health mandates prevented such investigations, leading research projects to use other forms of data collection, such as phone or internet-based data collection (Lobe, Morgan, and Hoffman, 2020). Even with the COVID-19 threat, research must continue. Data collection and research methods must be modified and improved in both quantitative and qualitative research to meet this need. Therefore, researchers accustomed to working in or with communities to collect data had to develop methods that avoided face-to-face interactions by using digital or non-digital means that achieve similar goals.

To collect quantitative data, Torrentira (2020) suggests using online tools through subscriptions (personal or institutional), using Google forms as a free and conventional platform, and using QR codes to generate electronic survey questionnaires. For qualitative research, data collection can be done using diaries and reflections from participants in place of direct observation. Interviews may be conducted via telephone or mobile phone, and focus group discussions can be conducted via videoconferencing

(Torrentira, 2020). Traxler and Smith (2020) posits the Delphi method as a valuable approach that researchers can employ to gather data during COVID-19 and to address trustworthiness or validity and credibility of their data. The Delphi method is a well-known method for determining a shared opinion among subject matter experts in order to provide an answer to a question being investigated (David and Roberta, 2020). It allows for reflection among participants, who can modify and reconsider their thoughts in light of the anonymized perspectives of others. The opinions are collected from the group of experts that are not physically assembled, normally through questionnaires (David and Roberta, 2020). The experts provide their responses in two or more rounds. Each round, the facilitator provides an anonymized summary of the experts' rationales from the previous round, along with the reasons behind them (Belton, Wright, Sissons, Bolger, Crawford, Hamlin, Taylor Browne Lūka, and Vasilichi, 2021). Results are determined by the mean or median scores of the final rounds after a consensus is reached based on a predetermined stopping criterion (e.g., number of rounds, consensus achieved, stability of results) (Belton et al., 2021).

Studies that applied the Delphi method during the COVID-19 pandemic

In Table 1, articles that used different types of the Delphi method to pursue a study due to the COVID-19 pandemic are presented. Several rounds occurred in each study as presented in the articles to reach a consensus. It took two rounds for two studies, three rounds for one study and four rounds for the other two to achieve a consensus. This confirmed suggestions that a consensus can be achieved between 2 to 4 rounds (Yeh, Van Hoof, and Fischer, 2016; Alarabiat and Ramos, 2019). The expert panels reached consensus that identified, evaluated, and validated the various authors' research objectives. Mummaneni, Burke, Chan, Sosa, Lobo, Mummaneni, Antrum, Berven, Conte, and Doernberg (2020) used video conferencing to facilitate feedback and emails to disseminate and receive feedback on the finalized protocols and checklists.

The Delphi method made it possible to access participants during COVID-19 through expert reviews without the need to meet in person (Eibensteiner, Ritschl, Ariceta, Jankauskiene, Klaus, Paglialonga, Edefonti, Ranchin, Schmitt, and Shroff, 2020; Fisher, Erasmus, and Viljoen, 2020; Mummaneni et al., 2020; Rajhans et al., 2020; Arifin, 2021).

Table 1 – Delphi method articles due to COVID-19

Article Title	Purpose	Delphi Type	Number of Rounds	Number of Panels	Consensus	Outcome
Consensus-based perioperative protocols during the COVID-19 pandemic.	To develop protocols necessary to optimise care for COVID patients to minimise the burden on hospital resources during the COVID-19 pandemic.	Modified	2	1	Frequency of agreement	A framework that minimises the strain that urgent/emergent invasive procedures and surgeries place on hospital resources during the pandemic
Adopting a modified Delphi	To derive a holistic competency	Modified; e-Delphi	4	1	Frequency of agreement	A framework that provided a strong foundation for

Article Title	Purpose	Delphi Type	Number of Rounds	Number of Panels	Consensus	Outcome
technique for revisiting the curriculum: a useful approach during the COVID-19 pandemic.	matrix for an optometry program for transformation of the program to competency-based education.					redesigning pedagogy and assessment methodology during the COVID-19 crisis
Applying Modified e-Delphi Technique: Guideline for HR Researchers and Practitioners for Developing Competency Profiles During COVID-19 Pandemic.	To develop a step-by-step guideline for developing an employee competency profile	Modified; e-Delphi	2	N/A	Frequency of agreement	The article narrated a methodological procedure that follows the restrictions and social distancing norms imposed during the COVID-19 outbreak using e-Delphi. The author points out that this method has proved to be more practical when considering experiences during the COVID-19 pandemic.
Rapid response in the COVID-19 pandemic: a Delphi study from the European Pediatric Dialysis Working Group.	The objective of this study was to rapidly gather expert knowledge and experience to guide the care of children with chronic kidney disease during the COVID-19 pandemic	Multi-center Delphi	4	N/A	Descriptive statistics	Thirteen COVID-19 specific topics of particular need for guidance were identified
Adaptation of the Delphi Technique for Electronic Application in the Food Industry.	This article reports on a successful electronic application of a classic Delphi procedure involving South African food industry specialists, reflecting on the local context and optimising their expertise to	Classical Delphi	3	1	Qualitative coding	In this article, the authors promote the use of the Delphi technique in electronic format for multiple reasons, namely possible wide application, affordability, and speed of the process

Article Title	Purpose	Delphi Type	Number of Rounds	Number of Panels	Consensus	Outcome
	elicit a context-specific definition for Food Literacy with all the associated dimensions.					

Discussion

This section presents a summary of the literature findings. This section is important as it provides evidence of the use of the Delphi method and a practical approach to add value to research and replace face-to-face interviews, considering the restrictions that were placed by the COVID-19 regulations.

Table 2 – Summary of the Successful Delphi Articles due to COVID-19

No	Article	Why Delphi	Author
1	Consensus-based perioperative protocols during the COVID-19 pandemic.	The authors developed a framework consisting of protocols used to guide perioperative care at University of California and Western US (UCSF) using a modified Delphi method due to the lack of data and time during a pandemic to create evidence-based guidelines for triaging invasive procedures.	(Mummaneni et al., 2020)
2	Adopting a modified Delphi technique for revisiting the curriculum: a useful approach during the COVID-19 pandemic.	Following social distancing norms imposed during the outbreak of COVID-19, the author presents a suitable, feasible, and scientific method for rapid transition in academia.	(Rajhans et al., 2020)
3	Applying Modified e-Delphi Technique: Guideline for HR Researchers and Practitioners for Developing Competency Profiles During COVID-19 Pandemic.	This article narrates a methodological procedure that follows the restrictions and social distancing norms imposed during the COVID-19 outbreak using a platform known as e-Delphi.	(Arifin, 2021)
4	Rapid response in the COVID-19 pandemic: a Delphi study from the European Pediatric Dialysis Working Group.	The modified Delphi approach is practical in responding to the COVID-19 situation, where researchers and practitioners, especially in HR, face data collecting barriers.	(Eibensteiner et al., 2020)
5	Adaptation of the Delphi Technique for Electronic Application in the Food Industry.	Delphi provides the ideal way to share the experiences and insights gained during the COVID-19.	(Fisher et al., 2020)

As observed in Table 2, these studies confirm the Delphi method design and its flexibility to the diversity of research and, more recently, surrounding circumstances. Because of its flexibility, the authors have tailored their research to accommodate the challenges that have been imposed by the COVID-19 pandemic, especially in conducting research the traditional way that is conducting face-to-face interviews, case studies, and observations. Thus, this study cements the Delphi method as a suitable approach to conducting research during the COVID-19 pandemic.

According to Hedding, Greve, Breetzke, Nel, and Van Vuuren (2020); Donohue, Lee, Simpson, and Vacek (2021) some students were having an even harder time trying to complete their degrees during the COVID-19 pandemic. These experiences ranged from feeling abandoned to finding ways to manage the disruptions of their dissertation and thesis progress. Below are some of the frustrations experienced by Doctoral and Masters students on how the COVID-19 pandemic impacted their studies.

- Availability of potential participants in their study was limited because the targeted population was high school leaders who were preoccupied with preparations for return plans.
- Research proposals were difficult to plan because they required significant travel to many places, and there was uncertainty about when/if those places would be safe. Timelines were difficult to establish during the COVID-19 pandemic.
- Some students were delayed because they could not start their data collection or had to put it on hold.
- Some of the researchers changed their data collection plans, requiring additional time for designing, writing up, evaluating, and implementing, thus extending the timelines of many of the studies.
- One approach was to move data collection online for researchers who had already collected data.
- Lockdowns, site closures, and the increased risk to participants made it impossible to conduct face-to-face experiments with human subjects, observations, interviews, and focus groups.
- Observations and interviews could not be done in organizations or schools, and the whole project relied on that data.
- The time required for making changes to research designs was problematic from the student's perspective who was trying to complete a project.

Further, due to the COVID-19 restrictions and the lack of access to possible participants, more students at South African universities opted to use the Delphi method in their studies. This finding was obtained by interviewing seven supervisors or co-supervisors from five South African universities who all indicated that at least two to three of their Masters and Doctorate students who had to complete their studies were forced to apply the Delphi technique. This technique was applied to either evaluate or finalize their developed models or frameworks as their final deliverables. Some students did manage to collect data traditionally, while most relied on the Delphi method to maintain the continuity and quality of the study. During the interviews, it was found that those who managed to collect data traditionally either through case studies or to get a representable quantitative sample had already started this process prior COVID-19 (before March 2020). Those who planned data collection during 2021 reverted to using expert reviews through the Delphi technique.

As one supervisor indicated: *“Two of my Masters’ students and one PhD changed their research protocols for ethical purposes to apply the Delphi technique as there was no other option”*. Another supervisor from another university also maintained that: *“We did try to get access to participants by either mailing them or telephonically accessing them, but it was a fruitless exercise as they either did not have access to stable Internet connections (especially in rural areas), or they indicated their unavailability via online platforms”*. As indicated by another supervisor: *“Their Masters student successfully contacted the participants and was awaiting approval from the district manager;*

however, as the COVID-19 cases were rising, they were unavailable". To maintain anonymity and privacy, none of the students' or supervisors' personal information can be disclosed.

Conclusion

This research explored and presented articles that successfully implemented the Delphi method during the COVID-19 pandemic to carry out research even with the COVID-19 restrictions implemented. Furthermore, the research identified participants who's academic studies were interrupted by the COVID-19 pandemic and had to adapt their research methodology to the Delphi method to complete their studies. The authors advocate the Delphi method as one of the best alternatives available for researchers, institutions, and academics to use as we lived in a world of COVID-19 disruptions and lockdown situations. The Delphi method is thus more suitable for identifying, verifying, and validating the study's outcome in situations where face-to-face access to participants is not possible and participants are based in different locations.

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Recommendations for sustainable post COVID-19 eLearning development in Rural Schools in South Africa

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Abstract

Prior to the COVID-19 pandemic, many ICT initiatives were implemented in rural schools across the country to improve teaching and learning. This paper discusses the various factors that contributed to the failure to sustain ICT initiatives. Due to the risk of infection associated with face-to-face contact during the COVID-19 Pandemic, eLearning proved to be the sole means of ensuring educational continuity. The objective of this paper is to highlight factors affecting sustainability and provide recommendations that can assist in ensuring sustainable ICT initiatives in rural schools after the COVID-19 pandemic. This is accomplished by conducting a scoping review to investigate the sustainability of ICT infrastructure to enable eLearning. The following academic databases are used for scoping literature reviews: ScienceDirect, IEEE Xplore, and search engines such as Google. A total of 41 papers out of 800 publications were deemed appropriate for the analysis. The findings show that physical, management, social, and educational conditions all have an impact on the sustainability of ICT initiatives; thus, addressing these components can ensure sustainability.

Keywords: (eLearning, COVID-19, ICT, rural-based schools, sustainability)

Introduction and background

The novel Coronavirus (COVID-19) is the cause of the highly contagious virus, which is passed from person to person through droplets from sneezing and coughing. Although the signs and symptoms of the virus are similar to those of a cold, it is severe and may cause serious illness and even death if not treated promptly by healthcare professionals (Zhu, Wei, and Niu, 2020). COVID-19 was initially discovered in Wuhan, China, in December 2019. After its discovery and the effects of the virus, the World Health Organization declared the virus a pandemic as it affected almost all nations (WHO, 2020). To flatten the curve and stop the spread of the disease, lockdown and staying indoors techniques were implemented (Sintema, 2020). On March 5, 2020, COVID-19 made its way to South Africa. As a result of lockdown and social distancing measures brought on by the COVID-19 epidemic, schools, training centers, and higher learning institutions were forced to

close (Ciotti, Ciccozzi, Terrinoni, Jiang, Wang, and Bernardini, 2020). South Africa's primary, secondary, and tertiary education systems have historically faced major challenges, such as large numbers of learners in classrooms, insufficient learner support material, a lack of clean water, insufficient and unsanitary 'bathroom' facilities, poor quality of teaching, and inadequate support, particularly in disadvantaged communities (Pillay, 2021). The COVID-19 pandemic exacerbated many of the challenges that learners and teachers already faced (Maree, 2022). Learning was up to one year behind schedule (UNICEF, 2021). Consequently, some matriculants had not written exams during that time, which also meant that learners in Grade 12 were not adequately prepared for the pending end-of-year exams (Maree, 2022). The South African Department of Basic Education (DBE) was unprepared for such a significant shift in the educational system (Maree, 2022). The unexpected change in the education system brought by COVID-19 had a significant impact on rural schools.

During this time, digital and online education (eLearning) became an integral part of the educational system where face to face contact posed the risk of infection. eLearning started in the late eighties and nineties as the first form of electronic education known as Computer-Based Training (CBT). This is considered the cornerstone of today's eLearning (Hubackova, 2015). The system itself made impressive progress. However, it lacked several eLearning features, like no time or location restrictions, and its content was not that extensive. Originating and developed in the United States, the information was first delivered only in text format, but in the early 1990s, browsers allowed users to add graphics to the text (Hubackova, 2015).

The upgraded system allowed communication between teachers and learners. Its main objective was to disseminate knowledge, but more importantly, to improve the educational system. However, there is a technological divide between urban and rural schools due to a lack of infrastructure and resources in rural schools (Zubane, Khoza, and Mlambo, 2022). The purpose of the study is to evaluate how COVID-19 contributed to the rapid adoption of eLearning in rural schools and to make recommendations to ensure eLearning sustainability post-COVID-19.

Methodology

Systematic reviews are research syntheses carried out by review groups with specialized expertise. They aim to locate and retrieve international evidence pertinent to a specific question(s). Systematic reviews adhere to a structured and predefined process and call for rigorous methods to ensure that the results are accurate and useful to the end users (Munn, Peters, Stern, Tufanaru, McArthur, and Aromataris, 2018). Scoping reviews offer a clear indication of the volume of literature and studies currently available as well as an overview, making them an excellent tool for determining the coverage or scope of a body of literature on a particular issue. When analysing new evidence and when it is not yet clear what more questions should be asked, scoping reviews are helpful (Munn et al., 2018). This paper was developed using a scoping review to investigate factors that affect the sustainability of ICT infrastructures to enable eLearning in South African rural schools. The databases used were ScienceDirect, IEEE Xplore and the search engine Google. The paper examined articles published between 2011 and 2022. The articles that discussed eLearning and rural schools; were written in English; and were relevant to the search were considered for inclusion. The exclusion criteria included non-English articles, alongside a screening process that eliminated duplicates, and abstracts. Out of 800 publications, 41 were appropriate for the study.

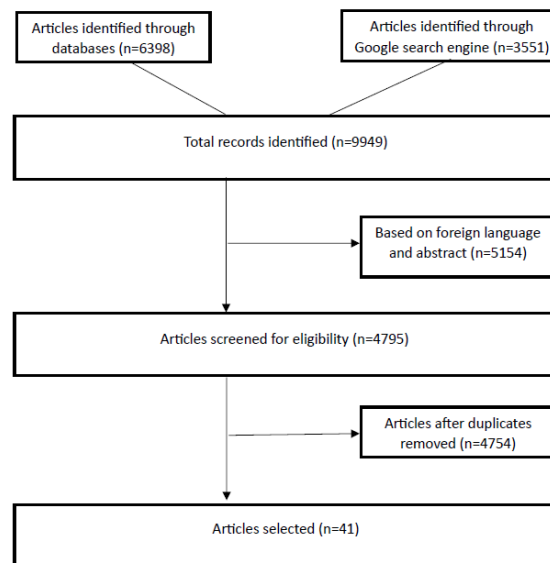


Figure 9: Process of record selection adapted from (Moher, Liberati, Tetzlaff, and Altman, 2009)

Literature

It is prudent to provide context and definitions for the terms 'eLearning' and 'rural learning' to ensure that the reader understands the contents of the paper.

eLearning is a method of constructing and validating knowledge through asynchronous and synchronous electronic communication. Internet connectivity and related communication technologies provide the backbone of eLearning. Hussain, Wang, and Rahim (2013) describes eLearning as using ICT resources to completely transform the learning process. Typically, eLearning is used in distance education, but it can also be used in conjunction with face-to-face instruction (Kahiigi Kigozi, Hansson, Danielson, Tusubira, and Vesisenaho, 2011). (Edem Adzovie and Jibril, 2022) define eLearning as any form of teaching and learning conducted electronically, such as through mobile phones or personal computers connected to the Internet. The authors broadened the definition to include audio/video recordings of lessons made by an instructor for the consumption of learners/students and vice versa. According to Al Rawashdeh, Mohammed, Al Arab, Alara, and Al-Rawashdeh (2021) eLearning offers more than just online content delivery. Knowledge sharing and collaborative learning enable individuals to connect and create a learning community in which part-time and full-time learners can actively participate in online degree courses selected from any location or place, providing people who are travelling or relocated, an easily accessible resource for experience and learning (Al Rawashdeh et al., 2021). In light of the outbreak of COVID-19, which forced all institutions in the country to switch to alternative methods of teaching and learning, an institutions survival was largely determined by its innovation, as well as the availability of the necessary infrastructure (Dwivedi, Hughes, Coombs, Constantiou, Duan, Edwards, Gupta, Lal, Misra, Prashant, Raman, Rana, Sharma, and Upadhyay, 2020).

The term rural settings refers to "farms and traditional areas that have a low population density, low economic activity, and a low level of infrastructure" (DBE, 2017:p6). In rural areas of South Africa, schools face a variety of challenges, including unstable electricity, high dropout rates, poor classroom infrastructure, and security issues (Adukaite, van Zyl, Şebnem, and Cantoni, 2017), and relevant to this study, the lack of qualified teachers and the lack of teaching and learning materials (Mestry and Ndhlovu, 2014). Consequently, the DBE recommended in their policy the increased diffusion of ICTs to rural schools to help reduce some of these problems, and benefit ICT stakeholders.

Pros and Cons of eLearning

Several educational institutions throughout the world were compelled to use online teaching and learning during the COVID-19 lockdown period to adhere to social distancing, and other public health measures implemented to contain the spread of the novel coronavirus (Kaisara and Bwalya, 2021). eLearning has created new opportunities for learning, such as making sure that learners are fully engaged since learning occurs in conjunction with texts, videos, sounds, collaborative sharing, and interactive graphics (Al Rawashdeh et al., 2021). Using the numerous eLearning technologies, learners are encouraged to collaborate, reflect, and build their own knowledge (Hošková-Mayerová and Rosická, 2015). Furthermore, it facilitates improved communication between instructors and learners and its flexibility allows learners the freedom to attend classes anytime and anywhere (Al Rawashdeh et al., 2021).

On the other hand, because eLearning is typically conducted in a remote and contemplative manner, this can result in a lack of learners involvement (Al Rawashdeh et al., 2021). In eLearning where evaluations are frequently conducted online, the authenticity of a particular learners work is a concern as almost anyone can complete a project in place of the learner themselves (Gherheş, Stoian, Fărcaşiu, and Stanici, 2021). Consequently, unethical activities such as cheating, and plagiarism may become more prevalent (Amzalag, Shapira, and Dolev, 2022; Chiang, Zhu, and Yu, 2022). The cost of data for accessing eLearning platforms can be an issue for both learners and students (Kaisara and Bwalya, 2021). The cost of data has been cited as a key barrier to successful eLearning adoption in developing countries (Kibuku, Ochieng, and Wausi, 2020). Furthermore, the difficulty of teaching practical courses, the absence of direct interaction with the teacher, and spending too much time in front of a computer, phone, or other mobile device are some of the disadvantages of using an eLearning platform (Stecula and Wolniak, 2022).

Measures taken to mitigate COVID-19's effect on the educational system.

eLearning technologies such as the Internet, radio, television, phone messaging, and email communication could be used to support continuity in the education sector (Basilaia and Kvavadze, 2020). In South Africa, Ghana, Eswatini, and Lesotho, online libraries, guidelines, resources, video lectures, and television broadcasts were implemented to continue the education process during the pandemic (Sengai, Mokhele, and Makumane, 2022). The Ghanaian used \$15 million of the money provided by the World Bank to implement a remote learning system to ensure continued learning, recovery, and resilience for basic education (World Bank, 2020; Okertchiri, 2021). To facilitate learning during lockdown, Eswatini's government teamed up with the country's two major mobile service providers to offer study bundles at reasonable rates (Pitikoe, Ferreira-Meyers, Bhebhe, and Dlamini-Zwane, 2021). According to Christie (2021), the DBE of South Africa appeared to respond more diligently to the impact of COVID-19 on

the school system. Lesotho's interventions indicated an insufficient level of readiness for technology integration across the curriculum (Sengai et al., 2022). Resources were provided to learners across all grades, including educational broadcasts on radio and television, eLearning through platforms such as Microsoft Teams and Zoom, as well as worksheets and exam papers (Sengai et al., 2022).

Discussion and recommendation

To transition from traditional teaching to an electronic environment, the use of eLearning has emerged in the context of modern information technology and has been incorporated into the educational programs of many schools (Msiza, Malatji, and Mphahlele, 2020). In an effort to raise educational standards and transition to paperless classrooms, many ICT initiatives were deployed throughout the country to improve not only the educational sector but also the rural areas. The section below discusses only two ICT initiatives (Classrooms of the future, and ICT4RED) that were implemented pre-COVID-19 Pandemic in South Africa:

Classroom of the future

According to Msiza et al. (2020), the Gauteng Department of Education (GDE) adopted the global eLearning trend with the goal of introducing "classrooms of the future." At a school in Gauteng, the first "classroom of the future" was unveiled by Cyril Ramaphosa, who was then the deputy president, and David Makhura, the then premier of Gauteng (Falanga, 2015). A total of 1800 grade 12 classrooms in 377 schools were equipped by July 2015. By July 2016, the project had covered over 2300 grade 11 classrooms (Mugani, 2020). Additionally, in 2017, 83 fee-paying secondary schools were added with the goal to integrate all rural secondary schools. To reach an additional 3100 classrooms, the project is currently focusing on the grade 10 rollout in rural schools (Mugani, 2020). Furthermore, to facilitate eLearning in schools, the government gave teachers the necessary training and development to equip them with the necessary skills. The GDE invested R 724 million in the 2017/2018 financial year to continue the rollout of its eLearning strategy as part of the implementation process (Msiza et al., 2020).

Any rural school that achieves a matric pass rate of 100% is automatically accepted into the project, receiving end-to-end support from grades eight through twelve (Mugani, 2020). All classrooms of the future schools have Internet access and have access to eLearning and ICT solutions (Mugani, 2020). The classroom of the future has improved instruction and learning, making it simpler and more enjoyable for teachers. Learners have gained confidence, especially in using technology, and their achievements have improved since 2015 (Mugani, 2020). Furthermore, the system allows matric learners to apply to tertiary institutions in an easy and cost-effective manner. School security has become a concern now that criminals are targeting schools with devices that deliver the benefits of the classroom of the future (Mugani, 2020). Despite some incidents of theft, all tablets are equipped with tracking devices (Mugani, 2020).

Following are some suggestions for how the classroom of the future will be different from current classrooms: With individualized instruction, online testing, and assessments, the classroom of the future is expected to be more creative and exciting. Schoolnet India (2022), state that learners will have more control over their educational experience.

- **Learning will become personalised:** A personalized environment emphasizes individual learner growth, often through skill-based and cooperative groups (Basham, Hall, Carter Jr, and Stahl, 2016). It is active and complex as it takes individual's

learning preferences and requirements into account. According to Pane, Steiner, Baird, Hamilton, and Pane (2017), teachers can have access to "learner profiles" that learners create in classrooms of the future to enable them to design personalized learning pathways for each individual based on their preferences, goals, weaknesses, and strengths.

- **Virtual and augmented reality:** The use of virtual and augmented reality technology allows learners to experience the content they're learning more realistically. With a handheld device, learners can travel around the world without ever leaving the classroom (King and South, 2017).
- **Flexible assignments:** Learners are not bound to a set of guidelines to prove their abilities through flexible assignments. Flexibility of assignments motivates them to research more, have enriching conversations, apply their knowledge, and learn more (Zayapragassarazan, 2020). In terms of evaluation, flexible assignments break the pattern of either correcting written assignments or reading through a set of similar information; instead, teachers are more likely to be interested in testing a learner's grasp of the subject (Sharma, 2021).
- **Cloud computing:** Cloud computing allows teachers and learners to collaborate and complete work from any device with an Internet connection. Kumar and Bhardwaj (2020:103) posit that cloud computing in education improves school performance, learner success, reduces teachers' workloads, and increases healthy competition among learners. Using cloud computing in classrooms of the future will allow teachers to take advantage of new and innovative classroom structures that allow learners to have more face-to-face time with their classmates at school while also being able to access lessons and assignments from home, resulting in a truly innovative and modern classroom (Vandis, 2019; Mali and Kothari, 2020).
- **Deep learning:** Is a technology that has the potential to completely alter the way that education is currently approached. By mimicking how the human brain works, deep learning machines will be able to engage in autonomous thinking and learning. For learners who need more assistance, this could have significant effects, such as matching them with teachers who are available through flexible scheduling or learning analytics tools. Future classrooms that emphasize deep learning will in many ways tailor each learner's educational experience to fit their particular needs and rate of learning (Gleason, 2020:300).

ICT4RED

From 2012 to 2016, Technology for Rural Education Development (ICT4RED) was a project that introduced technology (tablets and supporting ICT infrastructure) to 26 rural schools in the Nciba circuit of Cofimvaba in the Eastern Cape. The objective of the program was to support evidence-informed learning for policymakers and practitioners (Botha and Herselman, 2013). The ICT4RED initiative was a component of the Technology for Rural Educational Development (TECH4RED) research program, which aimed to improve rural education through technology-led innovation (Botha and Herselman, 2013). It was founded by the Department of Science and Technology (DST) in partnership with the Departments of Basic Education (DBE) and Education (ECDoE). ICT4RED was looking into the effects of giving tablets to 26 rural schools in the Cofimvaba school districts Nciba Circuit, which is the ICT emphasis of the TECH4RED program (Ford, Botha, and Herselman, 2014). The challenge was to implement technology in a way that would enhance teaching and learning, support sustainability beyond the project, and ensure true integration into existing educational processes, while managing very real logistical and infrastructure issues (Ford et al., 2014). The ICT4RED

initiative is based on the understanding that more significant changes to the educational system cannot be made by education departments alone but instead require the combined efforts of public and private partners, as well as civil society at the national, provincial, district, and circuit levels. Schools, provincial government, NGOs, and business sector organizations (working on comparable rollouts now) are all part of the target market (Herselman and Botha, 2014). The initiative's worth lies in its multidisciplinary implementation in a rural educational setting. The ICT4RED initiative was developed by leveraging knowledge from comparable international initiatives (Herselman and Botha, 2014).

All teachers were required to participate in the ICT4RED Teacher Professional Development Course as part of the initiative (Nkula, 2015). The course is made up of ten modules. Each module gave the teacher a fresh approach to teaching strategy, useful tools for assessment, and technological know-how (Botha and Herselman, 2013). The goal of the course was to transform teachers' practices from teacher-centred to learner-centred by utilizing hands-on teaching methodologies, therefore it goes beyond simply teaching learners how to use tablets (Botha and Herselman, 2013). Teachers receive a badge after finishing a module. There are one or more badges associated with each module. All teachers provided proof that they used the teaching method in the classroom and incorporated technology and topic knowledge (content knowledge) into a lesson to receive the badges. The badge facilitator receives the proof, examines it, and grants the badge (Botha and Herselman, 2013).

The Department of Science and Technology requested that the ICT4RED TPD course be modified and implemented in the Square Kilometre Array (SKA) e-Schools as part of the Human Capital Development mandate to stimulate a sustainable pipeline for local rural youth employment and community upliftment. The Department of Rural Development and Land Reform (DRDLR) contracted the CSIR in 2016 to install technology in 24 rural schools, this was done in order to build on the successes of the ICT4RED initiative (Botha, Herselman, Rametse, and Maremi, 2017). The DRDLR ICT for Education (ICT4E) initiative is the name of this endeavour. The DRDLR identified 24 rural schools in 7 regions of South Africa (Botha, Herselman, Musgrave, and Jaeschke, 2017). Unfortunately, the ICT infrastructures are not sustainable beyond the project due to the factors presented below.

Factors affecting sustainability.

Meurer, Müller, Simone, Wagner, and Wulf (2018) claim that it is difficult to sustain IT-based solutions. Furthermore, for a design outcome to be adopted, maintained, and finally further developed, it is necessary to investigate the circumstances both inside and outside of a research project. This is because sustainability is a bigger concern (Meurer et al., 2018). Despite the efforts made to enhance rural schools using ICT infrastructures and training for teachers in utilizing these devices, factors that impact sustainability are:

- i. **e-Readiness** – ICT4RED had great success equipping teachers with the tools they need to educate using technology and implementing 21st century teaching techniques at the school level (Ford, 2016). Unfortunately, local and provincial structures did not adopt this success (Ford, 2016). One of the issues was "readiness" at the school, district, provincial, and national levels (Dlamini, Meyer, Marais, and Ford, 2017). Traditionally, e-readiness assessments evaluate the physical, management, social, and pedagogical circumstances in place that lead to

receptiveness to the introduction of ICTs in order to determine the capacity of a school to use them (Dlamini et al., 2017).

- ii. **Social** – The social component of sustainability in this section focuses on the skills level provided to the beneficiaries of these ICT initiatives as discussed below:
 - **Skills** – Despite receiving adequate training on the utilization of these ICT infrastructures, it is easy to fall back on the traditional norm of teaching and learning. Cooperative education is one such strategy, combining classroom learning with training, a foundation to the concept of acquiring knowledge by doing. Training needs to be conducted between learners and teachers in rural based schools on the use of ICT devices and infrastructure. This will familiarize them with the many concepts such as device management, infrastructure maintenance, troubleshooting and security (UGWU and Nnaekwe, 2019). Most of the time, teachers in rural schools are required to teach a variety of subjects to a range of grade levels in a single class. Undoubtedly, this had significant effects on teachers' ability to organize lessons for each day and each period, balance their time between teaching various grade levels, carry out assessments of their learners' progress, and uphold discipline (Du Plessis and Mestry, 2019).
- iii. **Physical** – The focus of the physical sustainability component in this paper is on two factors: theft and connectivity. These elements are crucial because they are the main cause of unsustainable development. According to literature research, ICT initiatives are frequently implemented in schools but fail because of inadequate security, which leads to the theft of equipment after government projects.
 - **Theft** – When rural schools are connected, they frequently lack either basic security measures to prevent device theft or adequate training for teachers and administrators on how to use the Internet in an effective pedagogical manner (Msiza et al., 2020). Concerns about insurance prices are also brought up by security and device theft challenges. The money for ongoing device insurance must be independently provided by the schools. Many schools cannot otherwise afford insurance on their own, and the DBE has not increased its budgetary allocation for it. Due to their limited budgets, schools simply lack the resources needed to protect their equipment (Du Plessis and Mestry, 2019). As a result, after the ICT infrastructures have been implemented and set up in schools, they are often stolen. The time, money, and effort put into connecting the school will be lost if there is no insurance because the equipment won't be replaced (Du Plessis and Mestry, 2019).
 - **Connectivity** – A major problem in South Africa is network connectivity. Many schools are found in isolated rural areas, which makes it nearly impossible to establish a strong network connection. To ensure the continuity of online education, a sufficient bandwidth is essential. Otherwise, connections become incredibly slow and unreliable, making it difficult to broadcast, access resources, etc. (Graves, Abshire, Amiri, and Mackelprang, 2021). Additionally, eLearning is now more affected than ever before due to load shedding (electrical power outages). Electricity is a necessity for most network transmitters. In remote locations where transmitters are dispersed, this makes it difficult to access a stable connection. The bandwidth allocated becomes limited when there is an unstable network connection. Low bandwidth will cause multimedia streaming to malfunction, even causing video streaming to cease (Graves et al., 2021). Users of Internet connectivity in remote schools (teachers, learners, and SMT members) often complain about the inadequate Internet connectivity that hinders their productivity (Msiza et al., 2020).
- iv. **Management** – In order to accomplish specified goals in the most effective and efficient way possible, management is the process for organizing a company's

actions and resources (Griffin, 2021). The two projects mentioned above demonstrate how well the government plans every project, from selecting the beneficiaries to implementing ICT initiatives in rural schools. However, the government does not plan beyond the project, and as a result, the ICT infrastructures are not sustained beyond the project due to theft, financial restrictions, etc.

- v. **Educational Conditions** – Facilities in rural schools especially in primary schools, are mostly in an unacceptable state. Many buildings were erected using mud blocks many years ago (Du Plessis and Mestry, 2019). In some areas classes are held in incomplete classroom structures. The few classrooms that are completed are overcrowded during the rainy seasons. Many schools lack the essential infrastructure to function as safe, efficient, and effective schools. Most rural schools have no water, sanitation, or electricity. Not all schools are fenced in, which makes it easy for intruders to enter and vandalise the school. Textbooks need to be transferred to the few classrooms that can be locked. It then takes up time during the first lesson of the day to get these textbooks to the respective classrooms where the books are needed. In some of the rural schools, furniture is stolen and classrooms are often used as toilets, especially those classrooms that cannot be locked (Du Plessis and Mestry, 2019).

Recommendations

- The government should consider allocating a financial budget to cover tablet costs, maintenance, technical support, ICT insurance, data storage, and teacher ICT training.
- Other ICT initiatives prohibited learners and teachers from taking ICT infrastructures like tablets home for security reasons; this should be thought of to reduce theft. The school should create a plan that discretely assigns the tablets to teachers and learners so that the community and other learners are unaware of the identified individuals responsible for safeguarding these devices.
- To assist schools in managing their ICT infrastructures, the ICT4RED initiative trained ICT Champions (NARYSEC), who were paid by the government for a two-year period. However, after the contract expired, schools were left without support, and it was frequently not possible to find additional funding to extend the contract of the ICT Champions (NARYSEC). It must be mandated that all schools must hire competent, well-trained technicians who can provide technical support to teachers and manage networks on a permanent basis in order to ensure continuity (Mabila, Van Biljon, and Herselman, 2017). A budget must also be allocated for such a role from the department.
- Partner with private organizations to provide inexpensive broadband for the community and broadband access for rural schools. This will increase network connectivity and enable learners and teachers to stream and continue working and learning from home.
- The "implementation readiness assessment framework" developed by Dlamini et al. (2017) should be used by the government, as it broadens the definition of "e-readiness" to encompass all stakeholders in the educational value chain. The framework is meant to be utilized prior to the launch of an ICT4D project. The framework is intended to make it easier for the implementation team to recognize problems that should be given priority, attention, and management throughout the implementation process as they are anticipated to have a long-term impact on sustained benefit delivery. The school, the neighbourhood, and the supportive environment (Provincial and National Departments of Education) are all included in this. Additionally, it is necessary to evaluate how

prepared the implementation team is to interact with the environment (Dlamini et al., 2017).

- Job opportunities can also ensure sustainability in the rural areas, as many people are uneducated and unemployed. Unemployment creates a high rate of poverty and thus increasing theft in the rural areas.

Conclusion

Despite numerous ICT initiatives being deployed to rural schools to enhance pedagogical practices and classroom practices, most of these initiatives were not adopted as anticipated due to factors discussed in the discussion section of this paper. During the COVID-19 pandemic, when schools shut down and eLearning was the only way to ensure educational continuity, the factors that affect sustainability were not important. In this time, the South African educational system began to recognize the value of eLearning. The challenges that the schools faced during the COVID-19 pandemic were presented in the literature, and it became clearer that connection problems, data costs, and load shedding were the biggest problems that learners, students, teachers, and lecturers, particularly in rural areas, had to deal with. Although load shedding is not the focus of this paper, it is a problem that, regrettably, prevents learners from actively participating in school activities, particularly when it comes to online classes, online assignments, and online resource access. Prior to the COVID-19 Pandemic, theft, e-readiness, skills, the physical layout of the schools, and connectivity were barriers to the sustainability of ICT infrastructures. This paper shows that this is still the case today. This paper offers recommendations that the Government could consider when implementing future ICT initiatives in South African rural schools to ensure sustainable implementations of ICT initiatives.

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Effectiveness in maintaining academic integrity while using online proctoring for online assessment

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Abstract

The purpose of the study was to investigate the effectiveness of maintaining academic integrity while using online proctoring for online assessment. This study was motivated by the literature's concern that the lecturers' and students' perspectives of online assessment proctoring services remain unexplored. This is the gap in literature that this study intends to fill. The participants in this study comprised 106 lecturers and 592 students from the University of Technology, Faculty of Science in South Africa. A mixed-methods study was conducted. The data was gathered using The Invigilator Quality questionnaire with both closed-ended and open-ended questions. Quantitative data were analysed using SPSS's frequency distribution and percentages. It was also found that 83.9% of the lecturers attended proctoring tool training. It was found that some of the students felt that the proctoring tool was confusing and time-consuming because they had to write the test or examination, take photos, type, and upload. The findings revealed that some lecturers felt that the proctoring tool was generally good; however, it still did not prevent students from copying information and cheating. Higher education should move toward authentic assessments with a student-centred approach that promotes 21st-century skills required by the future graduate to survive in the current industry driven by digital technologies.

Keywords: academic integrity, proctoring tool, online assessment, learning management system, higher education

Introduction

The COVID-19 pandemic and an increase in online education brought about serious discussions and almost a moral panic about academic integrity (Marais, 2022). Higher education institutions across the globe started using proctoring solutions more frequently during the COVID-19 epidemic to monitor online assessments for remote learning and teaching. This sentiment is supported by (Balash et al., 2023) who advocated that indeed the COVID-19 pandemic's arrival altered the nature of education and expanded the use of remote proctoring technologies, which are intended to keep an eye on students as they take assessments outside of the classroom. However, there is a concern over how technology facilitates student cheating and suggests that students are getting away with widespread cheating in higher education (Marais, 2022). Furthermore, the concern is that the lecturers' and students' perspectives regarding online assessment proctoring services remain unexplored (Balash et al., 2023). Kaisara and Bwalya (2023) indicated that there is not much evidence of studies that concentrated on assessment information integrity in mobile learning environments. However, there is evidence of research on academic integrity in online learning environments (Kaisara & Bwalya, 2023). These authors argued that such research is essential, especially for countries with a large number of mobile devices, such as Africa, where students most frequently utilise mobile devices to access learning content on digital devices. The researcher was motivated by these concerns and needed to contribute to this gap in the literature.

Literature showed an alarming increase (720%) and 77% of higher education institutions (HEIs) that used and planned to use online proctoring during the pandemic (Balash et al., 2023). This trend was also observed in South African Higher education institutions, even at the Study University of Technology. The main aim of adopting the proctoring tools was to administer online examinations (Almutawa & Sruthi, 2022). There is a widespread belief that because students and lectures do not interact directly in online classes, cheating will be more common than it would be in a traditional classroom (Grijalva, Kerkvliet & Nowell, 2006).

There are several benefits of online assessment, including enhanced quality assurance, accessibility, rapid feedback, and greater flexibility regarding location and scheduling (Hartnett 2023). James (2016) identified widened question styles that include interaction and multimedia, greater impartiality, and greater reliability with machine marking as advantages of online assessment. These advantages were courageous and influenced the study university to engage in online assessment. However, Azis, Abou-Samra and Aprilianto (2022) argued that the common online examination issue is security. To oppose the security issue, Wuthisatian (2020) asserted that the best method for online assessment, should be proctored exams because they help ensure the requirements and security of an examination, the verification of student identity during the examination, as well as the standards and guidelines for academic integrity. For these reasons, that the study university applied online proctoring for online assessment to maintain academic integrity. Many products on the market today offer online proctoring, including Respondus monitor, Proctorio, B virtual, Loyalist, and ProctorU, to name a few (Almutawa & Sruthi, 2022).

The invigilator app was the online proctoring solution applied at the Study University of Technology in this study. The Invigilator is a cell phone-based proctoring tool that makes it possible to write non-venue-based assessments in a more regulated and supervised environment. The students utilised the App on their cell phones and the academics set it up on the web browser using their laptops. The application employs artificial intelligence to verify images, identify speech in recordings, and provide verification codes for learning management system integration.

The purpose of the study was to investigate the effectiveness of maintaining academic integrity while using online proctoring for online assessment. In this regard, the closed-ended questionnaire was utilised to establish the effectiveness of the use of the invigilator app by the lecturers and students to support the quality of online examination. Furthermore, open-ended questionnaire was used to investigate the experiences and challenged encountered by both the participants with the application of online proctoring.

Related literature

Academic integrity

Academic integrity is a determination to the fundamental values of honesty, trust, fairness, equity, respect, and responsibility, as well as demonstrating the application of these principles in one's behaviour (Marais, 2022). Kaisara and Bwalya (2023) describe academic integrity assessment as the systematic gathering of data on student learning using the time, knowledge, skills, and resources available to inform judgments that have an impact on student learning. The literature revealed that academic integrity has a positive effect on students' academic achievement by reducing cheating (Almutawa & Sruthi, 2022). For students to attain the intended learning outcomes of the programmes,

adherence to the principles of academic integrity is the most crucial aspect (Nurpeisova et al., 2023). It may be argued in this study that compliance with academic integrity should be mandatory to increase the quality of assessments in higher education as the contribution to improving sustainable development goal 4 of quality education. In this case, Nurpeisova et al. (2023) argued that respect for the values of academic integrity at the university teaches time management, effective prioritisation, organisation, efficiency and to imparting the solid knowledge and skills that cannot be acquired through cheating. Therefore, moving students online required remote proctored exams to assure academic integrity (Hartnett 2022). It was imperative in this study that such a phenomenon be investigated with the use of a mobile artificial intelligent proctoring tool during online assessments.

Online assessment

Almutawa and Sruthi, (2022) argued that during the pandemic, online assessments were a crucial component of the e-learning ecosystem. Since assessment significantly affects how effective online tests are, appropriate design was crucial during this time. This sentiment is supported by Azis et al. (2022) who emphasised that a proper strategy must be used to achieve the best outcomes while doing online assessments. It was observed, however, that the lecturers encountered challenges in designing assessment strategies that enhanced psychomotor and affective domains. Furthermore, the literature revealed that when creating online tests, academics face obstacles and constraints that force students to concentrate solely on the cognitive skills (Azis et al., 2022). These could be resolved by applying alternative assessments relating to project-based learning, authentic assessments, open book examination, assessments that require students to apply critical thinking and problem-solving for example. This could result in the improvement of students' academic performance and obtaining better scores. In this vein, Kaisara and Bwalya (2023) argued that students' assessment results are extremely important in determining their future careers, as well as their economic and social possibilities. However, many students may find cheating appealing due to the pressure to achieve excellent marks (Kaisara& Bwalya, 2023). Online assessment is also thought to enhance the likelihood of cheating in general (James, 2016). This harms the training programmes' reputation and diminishes the value of the credentials in the eyes of prospective employers (Azis et al., 2022). It is for these reasons that the security-enhanced online assessment systems are employed as an alternative for preventing fraud and cheating (Azis et al., 2022). Wuthisatian (2020) indicated that many higher education institutions have adopted and implemented a proctored exam policy for their online classes to address these challenges and maintain the academic integrity of online learning. Under this policy, students who are registered in an online class are required to take exams in a proctored setting. This practice was not observed at the study university, there was no proctored exam policy in place. Due to the COVID-19 restrictions and the national lockdown, the institution had to implement the artificially intelligent invigilator app as a solution to maintain academic integrity because the majority of the students were studying with the use of their mobile devices (Simelane-Mnisi, 2022). Wuthisatian (2020) argued that examinations that are proctored assure the exam requirements and security, student identification verification during exams, and the norms and rules governing academic integrity.

Use of proctoring tools in higher education

Since there are no geographic restrictions, online exam proctoring makes it possible for students to access educational resources and write exams online (Raman, Vachharajani

& Nedungadi, 2021). Almutawa and Sruthi (2022) stated that some lecturers find the automated method more convenient because it eliminates the need for human proctor interaction and instead uses artificial Intelligence. For effective use of the proctoring tools and to maintain the ethical standards and academic integrity, lecturers and students need to be provided with training and guidelines for the online proctoring approach (Almutawa & Sruthi, 2022).

Maintaining academic integrity is a requirement for each exam that is proctored. The purpose of this proctored examination is to ensure both the academic integrity of the online course and the security of the examination process (Wuthisatian, 2020). Therefore, to identify and prevent cheating, online assessment systems typically require access to users' personal data, including camera photos, screenshots, and Global Positioning System (GPS) positions (Topuz et al., 2022). Another form of preventing cheating during online assessment is to use audio proctoring to detect potential voice-based cheating. Online cheating can be avoided by using a secure software remote proctor, which includes a 360-degree camera and a fingerprint scanner (Valizadeh, 2022). In addition, this author further stated that some software incorporating an e-proctoring system and authentication can catch cheaters in the act and prevent them from by creating a secure environment for managing online exams. In this study, the proctoring tool was used on entry level of smart phone to accommodate the socio-economic background of the students. Cheating was prevented by taking a selfie, scanning the quick response code, using the one-time password (OTP) and by capturing the movement by the GPS of the people nearby.

Methods

The question posed in this study was: How did the lecturers and students maintain academic integrity while using online proctoring for online assessment? To answer this question, the pragmatist philosophy was used. It was used because pragmatists are permitted to propose the method and approach that would best address a given research question, providing a conceptual framework for the use of both quantitative and qualitative methods (Goles & Hirschheim, 2002). In this case, the mixed methods with an embedded design was applied. Mixed-methods research investigates the study problem by combining quantitative and qualitative approaches to get a deeper understanding of the phenomenon at hand and guarantee the accuracy of the conclusions, (Plano-Clark & Ivankova, 2016). These authors stated that in an embedded design, one data set plays a useful, supporting role in a study that is predominantly based on another data type. In this study, The Invigilator Quality questionnaires with both closed-ended and open-ended questions were used to collect data simultaneously. The data were analysed separately, and quantitative data were analysed using the SPSS frequency distribution and percentages. In addition, qualitative data analysis was conducted using Saldaña's thematic method of analysis (Saldaña, 2015). Thematic analysis is an efficient method for analysing qualitative data through coding (Saldaña, 2021). The Study University approved the ethics conduct.

Participants

The participants in this study comprised 106 lecturers and 592 students from the University of Technology, in the Faculty of Science in South Africa. The study's participants were selected using stratified purposive sampling (Cohen et al, 2018). The researcher selected academics from the population of the one faculty at the Study University of Technology in South Africa. Both the lecturers and the students who completed the online survey were sampled. Furthermore, the researcher used purposive

sampling to select a sample to address the qualitative aspect of the study. In this case, 28 students, two from 14 Departments and 14 lecturers were sampled.

The results presented in Table 1 in accordance with the gender, position, employment and age of the respondents. The results revealed that, based on the gender and position, 62.9% of the lecturers were in a lecturer position. Of these lecturers, less than half, namely, 43.8% were females. This was followed by 14.3% of the lecturers in a junior lecturer position. The results showed that 11.4% of these lecturers were females. In terms of gender and employment, the results revealed that 64.2 % of the lecturers were employed full time. Of these lecturers, less than half, namely, 48.1% were females. Concerning the gender by age, the results showed that more than a quarter (34.0%) of the lecturers' ages ranged between 25 and 35 years. Amongst these lecturers, 19.8% were females. The results also revealed that a quarter, namely, 24.5% of the lecturers' ages ranged between 46 and 55 years. Female made up 17.0% of these lecturers.

Table 1. Cross-tabulation of lecturers' biographical data

		Male	Female	Total
Position	Professor	6 (5.7)	-	6 (5.7)
	Associate Professor	1 (1.0)	1 (1.0)	2 (1.9)
	Head of Department	1 (1.0)	3 (2.9)	4 (3.8)
	Senior Lecturer	3 (2.9)	6 (5.7)	9 (8.6)
	Lecturer	20 (19.0)	46 (43.8)	66 (62.9)
	Junior Lecturer	3 (2.9)	12 (11.4)	15 (14.3)
	Lab Technician	1 (1.0)	2 (1.9)	3 (2.9)
Total		35 (33.3)	70 (66.7)	105 (100)
Employment	Full time	17 (16.0)	51 (48.1)	68 (64.2)
	Part-time	18 (17.0)	17 (16.0)	35 (33.0)
	Fixed-term Contract	3 (2.8)	3 (2.8)	3 (2.8)
Total		35 (33.0)	71 (67.0)	106 (100)
Age	25-35	15 (14.2)	21 (19.8)	36 (34.0)
	36-45	5 (4.7)	19 (17.9)	24 (22.6)
	46-55	8 (7.5)	18 (17.0)	26 (24.5)
	56-65	7 (6.6)	13 (12.3)	20 (18.9)
Total		35 (33.0)	71 (67.0)	106 (100)

The results in Table 2 depict the students' gender, level of study and their ages. Regarding the gender and level of study, the results showed that less than half, 40.0% of the students were in their third year. Amongst these students, more than a quarter, namely 27.0%, were females. This was followed by more than a quarter, 26.7% of the students being in first year. It can also be seen that 18.9% were females. In terms of gender by age, the results revealed that less than half, namely 47.8% of the students' ages ranged between 21 and 25 years. Of these students, more than a quarter, 32.4 were females. This was followed by 23.0% of the students ages ranging between 18 and 20. Of these students 18.9% were females. The researcher can argue that in terms of gender, in this study, the females in both the groups participated. This implies that more females are pursuing their studies in science related discipline.

Table 2. Cross-tabulation of students' biographical data

		Male	Female	Total
Level of study	First Year	46 (7.8)	112 (18.9)	158 (26.7)
	Second Year	34 (5.7)	84 (14.2)	118 (19.9)
	Third Year	77 (13.0)	160 (27.0)	237 (40.0)
	Advance Diploma	18 (3.8)	36 (6.1)	54 (9.1)
	Postgraduate	6 (1.0)	19 (3.2)	25 (4.2)
Total		181(30.6)	411 (69.4)	592 (100)
Age	18-20	24 (4.1)	112 (18.9)	136 (23.0)
	21-25	91 (15.4)	192 (32.4)	283 (47.8)
	26-30	21 (3.5)	53 (9.0)	74 (12.5)
	31 and above	45 (7.6)	54 (9.1)	99 (16.7)
Total		181 (30,6%)	411 (69.4)	592 (100)

Instrument and procedure

The Invigilator Quality (TIQ) questionnaire with both closed-ended and open-ended questions for the lecturers and students were used to collect data simultaneously.

The invigilator quality closed-ended questionnaire.

Section A of the questionnaire collected information on the biographical data of the participants. Section B gathered quantitative data about user satisfaction about the Invigilator quality. The ratings used on the scale were as follows: 1 = Strongly Agree, 2 = Disagree, 3 = Neutral, 5 = Strongly Disagree. For the lecturers, the Invigilator quality (TIQ) closed-ended questions included six items and nine items for the students.

The invigilator quality open-ended questionnaire

Part C of the TIQ open-ended questionnaire consisted of two questions, which both the participants were asked. The questions asked were: (1) Describe your experience of the invigilator app. (2) Were there any challenges you encountered with the invigilator app? Yes or No. Elaborate.

Results and discussion qualitative findings

Reliability

The Cronbach's alpha values (Cronbach, 1951) were.95. The items' alpha values varied from 0.94 to 0.95. This implied that both participants' levels of internal consistency with the items were fairly high. Above.90 was shown to be the highest scores, which are even more dependable than 80 (Tavakol & Dennick, 2011).

Validity

An instrument is said to be valid if it is able to measure what is to be measured or desire (Simelane-Mnisi & Mji, 2017). In this study, the validity was measured using the Pearson Product Moment Correlation using SPSS by correlating each item questionnaire score with the total score. For the academics, the correlation value between the item with the total score (rxy. Sig (2-tailed) is at the significant level of 5%, while the N is the total of the participants is 106. On the other hand, for the students, the correlation value between the item with the total score (rxy. Sig (2-tailed) was at the significant level of 5%, while the N is the total of the participants is 592. It can be concluded that based on the Sig (2-tailed) of $0.000 < 0.05$ the items of both the participants were valid.

Results from the closed ended questionnaire

Table 5 shows the results in respect of the six items for the lecturers. In terms of the six items relating to TIQ, it may be observed from the table that, in TIQ1, the lecturers had to indicate whether they had attended the invigilator app training. The table shows that about 83.9% of the lecturers indicated that they agreed with this statement. This finding suggests that most lecturers were empowered regarding the use of the proctoring tool. This finding is supported by Balash et al. (2023) who argued that it is crucial to provide lecturers with training and raise their awareness of the privacy and security challenges that the proctoring tools bring to students, However, these authors reported that many lecturers in their study indicated the need for training to comprehend the proctoring technology better. It is critical to empower lecturers with training on the use of any new technology in education. If lecturers feel comfortable using the tool, it reduces anxiety and increases its use among the students. The results revealed that the majority (82.1%) of the lecturers agreed that they were able to create instructions on the learning management system (LMS) regarding the invigilator for tests/examinations. This finding suggests that lecturers were able to provide guidance to students on the use of the proctoring tool during the assessments. The results also showed that more than three in four (79.2%) of the lecturers indicated that they were able to set up the invigilation to reduce cheating and academic dishonesty with the application of the invigilator dashboard. This implies that lecturers were confident about using the system dashboard to activate the relevant settings to detect cheating during online examinations and tests. In this case, Nurpeisova et al. (2023) argued that to prevent problems related to academic dishonesty, a proctoring system can offer lecturers a useful and affordable strategy for lowering academic dishonesty.

Table 5: Lecturers results from survey questionnaire

Item	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
TIQ1	65 (61.3)	24 (22.6)	6 (5.7)	6 (5.7)	5 (4.7)
TIQ 2	61 (57.5)	21 (21.7)	10 (9.4)	6 (5.7)	6 (5.7)
TIQ 3	63 (59.4)	18 (17.0)	8 (7.5)	7 (6.6)	6 (5.7)
TIQ 4	62 (58.5)	25 (23.6)	29 (25.0)	5 (4.7)	6 (5.7)
TIQ5	45 (42.5)	29 (27.4)	14 (13.2)	7 (6.6)	11 (10.4)
TIQ6	23 (21.7)	23 (21.7)	26 (24.5)	12 (11.3)	22(20.8)

The results in Table 6 showed that most of the students (82.8%) were able to follow the instructions on the invigilator during examinations/tests. This finding supports (82.1%) of the lecturers who indicated that they created instructions on the LMS regarding The Invigilator for examinations/tests. The study by Hartnett 2023 indicated the opposite regarding the instructions provided to students to use the proctoring tool during examinations. Their students indicated that they needed assistance because they thought the instructions for configuring their computers to take the examinations. were insufficient as the information on the websites for the proctoring software company and the university appeared to be extremely ambiguous. James (2016) argued that after resolving technical challenges, the proctoring company’s level of support was deemed insufficient, the instructions did not address the problems with utilising a Mac computer.

The results revealed that most of the students (82.6%) managed to upload a selfie on the invigilator app. This implies that the artificial intelligence on the mobile proctoring

tool allowed the students to take their photos during the examination to check if they are relevant or the same student. This process was meant to strengthen academic honesty among the students. Due to the restrictions imposed by the tools, students are unable to cheat and are motivated to behave honestly for fear of being discovered and reprimanded by the software Balash et al. (2023).

Table 6: Students results from survey questionnaire

Item	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
TIQ1	289 (50.3)	185 (31.3)	78 (13.2)	22 (3.7)	9 (3.7)
TIQ 2	286 (48.3)	188 (31.8)	80 (13.5)	28 (4.7)	10 (1.7)
TIQ 3	286 (48.3)	204 (34.5)	71 (12.0)	22 (3.7)	9 (10.5)
TIQ 4	295 (49.8)	194 (32.8)	72 (12.2)	20 (3.4)	11 (1.9)
TIQ5	225 (38.0)	171 (28.9)	119 (20.1)	50 (8.4)	27 (4.6)
TIQ6	249 (42.1)	180 (30.4)	104 (17.6)	36 (6.1)	23(3.9)
TIQ7	289 (48.8)	185 (31.3)	79 (13.3)	23 (3.9)	16 (2.7)
TIQ8	225 (43.1)	162 (27.4)	112 (18.9)	38 (6.4)	25 (4.2)
TIQ9	258 (43.6)	134 (22.6)	118 (19.9)	51 (8.6)	31(5.2)

The results showed that 82.1% of the students were able to log onto the invigilator App. The results revealed that most of the students (80.1%) were able to scan the quick response (QR) code. Scanning of the QR code was also another artificial intelligent security measure that was embedded in the invigilator app to prevent unauthorised students from taking the test. It may be argued that these security measures were meant to increase the academic integrity regarding the use of cell phones. In this case, Kaisara and Bwalya (2023) emphasised that understanding information integrity solutions for mobile learning assessments helps increase stakeholders’ trust in the quality of mobile learning. Balash et al. (2023) opined that academic integrity is enforced via proctoring tools, but students’ honesty is not motivated by their ethical values or their desire to learn. The same students also indicated that they took the test or examination on the LMS using the invigilator app for invigilation. Halaweh (2021) emphasised that students should be trained on the proctoring features inbuilt on the LMSs such as like Blackboard and Moodle.

Qualitative findings

Lecturers and students’ invigilator app experiences

The theme of the invigilator app experiences emerged from the question: Describe your experience of the invigilator app. The findings showed that the training on the use of the invigilator app was conducted for both students and lecturers. It is worth pointing out that the institution training was conducted by the service provider. The instructional designer provided further guidance and support in the form of consultation time in the faculties. Lecturer 1 revealed that the training of “the app was extensive for all staff and students. The app was friendly with regard to many devices, it does not really need expensive smart phones.” It was found the lecturers found the app easy to use even though the struggle with analysing the results. Lecturer 13 said “It was easy to use the app but difficult to analyse the results.” Lecturer 14 stated “It is an easy App to create exams but tricky to view and obtain result.

The findings revealed that lecturers found the invigilator app to be good even if it did have some of the functionalities. Lecturer 2 mentioned “The proctoring tool in general was good; however, it still did not prevent students from cheating. Lecturer 10 said “The Invigilator app is a good idea. Not all the students entered their one-time-pin. I am not

sure what the penalty for this is. Some of the lecturers felt that more features should be included on the invigilator proctoring tool. Lecturer 11 stated “It was a good app, although I feel it needs more features like a video recording of students when writing the assessments.” Students have to understand the topic because proctoring is a method for identifying and lowering the probability of cheating on the exam (Nurpeisova et al., 2023).

It was found that some of the students had a good experience using the invigilator app on their cell phones, while others had a bad experience. In terms of a good experience, it was found that most of the students mentioned that the invigilator app was “good, excellent, fair, smooth, awesome, great, and simple to use.” Some of the students indicated that they did not encounter any problems. It was found that some of the students did not attend training as it was organised, and they were confused about using the system but were able to work around it. Student 3 said, “It was fine, but it made me feel scared when writing the examination because I was not introduced to it earlier.” It was also found that students found mock tests appealing because they were meant to practice; however, not all the lecturers conducted them. Student 5 mentioned, “The app is impressive, but personally, I think each subject code should set up a mock test to get students used to all the mechanics of the app.” It was also found that some of the students needed more practice. Student 17 indicated, “Well, as I mentioned previously, it takes practice to master it, so I managed.”

Regarding the students who had a bad experience with the invigilator app, they indicated that it was “bad, very unpleasant, confusing, and time-consuming.” Student 22 said, “It is confusing. You need to have enough time.” Student 24 indicated, “It was confusing and time-consuming because you have to write, take photos, type, and upload.” It was found that some of the students indicated that the invigilator app did not work nicely and that they encountered challenges with authentication. Student 20 indicated, “Sometimes the invigilator app did not work nicely.” Student 19 mentioned, “It is a challenge to some of us. The invigilator app has errors sometimes when you are about to write, and you end up writing the test without it. Student 25 said, “The invigilator app is very hard to work around, and sometimes it uploads the pictures late. Student 26 stated, “The picture quality needs to be improved.”

Challenges encountered by lecturers and students

The theme, invigilator app challenges emerged from the question: Were there any challenges you encountered with the invigilator app? Yes or No? Elaborate. The lecturers identified several challenges relating to students struggling with submissions, students were unable to upload their answer scripts on the app, time-consuming, a lack of time to listen to audio recording, students were unsure of the process, the lack of standard penalty when students were found cheating, no clear policy on what to do with students that might have failed the app test, late uploads on the LMS and, the app did not prevent cheating. It can be argued that lecturers’ challenges arose during the use of the invigilator app by the students. Ryznar (2023) emphasises that institutions should ensure that students are aware of the consequences of cheating and the value of academic integrity. Furthermore, it was clear that the lecturers were expected to analyse the data captured by the system during the examination. One can argue that this was a daunting task which was not supposed to be done by the academics. However, the invigilation department should have monitored the situation and put measures in place for those students who cheated. It may also be argued from these challenges that the purpose of the proctored examination to ensure

academic integrity seemed to be problematic. This sentiment is supported by Wuthisatian (2020) who stated that the objective of this proctored exam is to protect both the security of the examination process and the academic integrity of the online assessment.

The findings revealed mixed feelings regarding the challenges encountered by the students. Those who did not encounter challenges for example, Student 1 said, “No, it was just normal and good.” Student 3 indicated, “No everything was going good.” Student 4 said, “I did not encounter any problems so far.” Student 14 mentioned, “No, everything went well.” Student 20 said, “No problems at all.” Student 22 indicated “No, there were no challenges.” Student 23 stated “No. All went well.” Student 11 declared, “No, by inserting the correct QR code the app will not give any difficulties.” These findings are supported by Almutawa and Sruthi (2022) who stated that students are more accepting of online proctoring when it has no negative effects on their academic performance. Furthermore, online proctored examinations and tests are necessary to ensure academic integrity while students undergo online assessments (Hartnett, 2022).

The findings revealed that students who encountered technical challenges experienced it mostly with the invigilator app regarding uploading the documents, scanning QR code and the network. It was found that the students were unable to upload the documents on the app. In this case, Student 9 confirmed, “Yes. I struggled with uploading.” Student 5 said, “Yes, it did not upload sometimes.” Student 12 uttered, “I struggle sometimes to upload the files and documents requested.” Student 17 admitted, “Yes, it was challenging to upload my question paper onto the LMS, because we could not exit the invigilator app. So, I had to upload my answer sheet using the printer which took a lot of time.”

In terms of the QR code, Student 6 mentioned, “The QR code was not working when you have to write your test.” Student 18 said, “Sometimes it would not scan the QR code even if you scanned it before the time elapsed. It is so sad.” It was found that some of the students experienced network challenges. Student 10 replied, “Yes. Network issues” and Student 28 said, “It was mostly network issues. Browser compatibility issues, exam anxiety, and slow internet connections are other challenges that students encounter when using online proctoring (Almutawa & Sruthi, 2022).

Conclusion

It was stated that the main intention of implementing proctoring tools was to deliver online exams since the security of the examinations is problematic because cheating is more common than it would be in a conventional educational environment. These factors led to the implementation of several online proctoring solutions for online assessments to safeguard academic integrity. It can be seen that the Study University adopted the mobile online proctoring solution known as the invigilator app. The reason was to support the vast majority of the students who used cell phones for learning. It may be argued that this study contributed to the body of knowledge about the integrity of assessment information in mobile learning environments.

In light of the study’s findings, it is evident that the lecturers and students were trained on the proctoring features of the invigilator app. It was mentioned that the service provider conducted the institution's training, and the instructional designers provided further guidance and support in the form of consultation in the faculties. Through the training, lecturers succeeded in creating clear proctored examination and test instructions and guidance on the LMS. The instructions and guidance had a positive impact on the students, as they knew exactly what was expected of them during the examination.

It may be concluded from this study that most of the students managed to follow the artificial intelligence on the mobile proctoring tool for authentication as requested. In this case, most of the students succeeded in scanning the QR code, uploading a selfie, and entering the OTP during the examinations or tests. All these measures were carried out to ensure the accuracy of the student taking the examinations or tests. It may be argued that these security measures were meant to maintain academic integrity while students used their cell phones. It may be observed from this study that lecturers and students reported good experiences using the invigilator app, while others had bad experiences. It was discovered that most of the challenges identified by the lecturers relate to student uploading and submission of the scripts, lack of time to analyse dashboards to detect students who cheated, and lack of institution policy on the use of proctoring tools. It was also discovered that some of the students did not encounter challenges, whereas others did.

Recommendations

It is recommended that the service provider include additional features such as video recording to improve authentication and proctoring. It is critical that institutions of higher learning use a proctoring tool that accommodates the socio-economic background of the students. The institution's invigilation office should monitor the proctored examinations; it should not be the lecturer's responsibility, as they are not clued up about the measures in place to prevent cheating students during the examinations. An institution of higher learning needs to create awareness of academic integrity among its stakeholders. A policy needs to be instigated on the use of proctoring tools. Higher education should move toward authentic assessments with a student-centred approach that promotes 21st-century skills required by the future graduate to survive in the current industry driven by digital technologies. A further study could be conducted with a larger sample. The research study could also be conducted in other faculties and institutions in a similar context in higher education.

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Evaluation of the performance and experience of the students learning with AI systems

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Abstract

The introduction of AI-powered technology has created a batch of new opportunities in a variety of industries. In the education domain, AI systems are used not only to improve students' interaction skills, but also to assist teaching faculty by bringing automation. The use of AI-Systems in education improves connectivity, efficiency, and reduces uncertainty in interactions. They can easily provide a focused, personalized, and result-oriented online learning environment, which is exactly what today's educational institutions require. Despite the positive implications of AIs' impact on educational transformation, there appears to be a debate about their inherent advantages and consequent benefits in comparison to previously existing standards. Research suggested for an evaluation of the effects of AI-supported learning systems on students' performance and perceptions rather than the effectiveness of AI systems. This paper investigated students' learning experiences and perceptions of existing AI systems. Several factors were considered, including student learning performance, learning motivation, learning anxiety, self-efficacy, and cognitive load. A survey was conducted using questionnaire as instrument of data collection. The collected data was analysed with a standard statistical analytical software. The findings show that a larger proportion of the participants (higher education students) believe that using AI systems in teaching and learning is beneficial and improves their learning experiences. This paper makes meaningful contributions to the literature that explores technology acceptance in education. Firstly, it provides more insight about the students' level of experience when using AI systems for teaching and learning processes, and secondly, it may assist higher education institutions in determining how and which areas of technology implementation for educational purposes can be improved.

Keywords: Artificial Intelligence, Student performance, Learning experiences, Perceptions, Education

Introduction

The primary stakeholders in educational institutions are the students, and the effectiveness of educational institutions is crucial in producing highly skilled graduates and postgraduates (Kahn et al., 2021). Every higher education institution is working hard to maintain quality and good reputation within the educational sector. One of the key roles in teaching is to provide a good learning experience to students. Klemenčič and Chirikov (2015) stated that quality education and a good learning environment produce good learning experiences, and student experiences have become the key component of quality

assurance in higher education. Learning experiences influences the attitude of students in achieving a good academic performance (Laguador and Dotong, 2020; Soyer and Kirikkanat, 2019). The need to improve the performance and learning experiences of students has resulted in the use of digital technologies such Artificial Intelligence (AI) tools for teaching and learning purposes in higher education.

The use of AI tools in education is exponentially increasing. Some of the AI tools adopted for teaching and learning purposes include intelligent assistant (Okonkwo and Abejide, 2020-2023), teaching tool (Chen et al., 2020, Clariza et al., 2018), predictive tools (Alyahyan and Düştegör, 2020), and learning management system (LMS) (Blackboard). In recent years, AI technologies have been embraced and popularized in educational system. Intelligent assistant provides students with contents for personalised learning purposes and instant response to their queries. Students use eBooks through their tablets and laptops instead of hardcopy book. Lecturers deliver contents using Microsoft Teams, Google classroom, blackboard, and others. LMS is being used for administration, reporting, documentation, assessment, and tracking of student activities.

AI-Systems are used in education to increase connectivity, efficiency, and reduce interaction uncertainty. They can easily offer an online learning environment that is targeted, individualized, and results-oriented, which is exactly what today's educational institutions demand. Despite the positive implications of AIs' impact on educational transformation, there appears to be a debate about their inherent advantages and consequent benefits in comparison to previously existing standards (Okonkwo and Ade-Ibijola, 2021). Hwang et al. (2020) suggested for an evaluation of the effects of AI-supported learning systems on students' performance and perceptions rather than the effectiveness of AI systems. Academic performance is however a source of worry for higher education students (Laguador and Dotong, 2020). According Klemenčič and Chirikov (2015), we still do not completely grasp what students go through once they are enrolled in higher education, which is a problem (Klemenčič and Chirikov, 2015). Furthermore, it is not clear how the use of AI algorithms impacts higher education activities (Ouyang et al., 2022). There is a need to investigate the implications of AI in modern education (Martín-Núñez et al., 2023).

This study aims to evaluate the Performance and Experience of higher education Students Learning with AI Systems. Some factors were considered, including learning performance, learning motivation, learning anxiety, self-efficacy, and cognitive load. Thus, the research question is “*What effects does using AI systems have on students' learning and performance?*”

The study offers significant contributions to the literature on technology acceptability in education. First, it gives additional insight into students' levels of expertise when utilizing AI systems for teaching and learning processes, and second, it may aid higher education institutions in evaluating how and which aspects of technology deployment for educational purposes may be enhanced.

Background information

This section presents the theoretical information surrounding the topic under study including AI in education, student learning experiences, and academic performance.

Artificial Intelligence in Higher Education

The term "AI" refers to technology that can carry out operations that require a specific level of intelligence—a tool or machine that has been trained to perform tasks like those performed by a human or person. Ade-Ibijola and Okonkwo, 2023). The use of AI in the educational system is becoming the norm, especially after the COVID-19 pandemic, resulting in dramatic changes in traditional techniques. Some of the AI technologies being used in education today are adaptive learning systems, assistive technology, data and learning analytics, assessment tools, management tools, and academic research tools (Mahendra, 2023; Owuor et al., 2013).

Adaptive learning systems: The application of AI technologies in education includes the development of adaptive learning systems such as intelligent tutoring system and coding platforms (Smutny & Schreiberova, 2020; Daniel et al., 2020). These tools assess student performance using Machine Learning (ML) algorithms and modify exercises accordingly (Imhof et al., 2020; Mahendra, 2023). Adaptive learning can enhance student performance dramatically. It allows one to learn at one's own pace without boredom.

Assistive technology – AI technologies that provide specialised help to students such as Grammarly AI tool. These technologies can also assist students with impairments in understanding their course contents more thoroughly (Mahendra, 2023). It accomplishes these using simulations and visualisation. Speech synthesis for effective communication and intelligent tutoring for personalised learning are examples of these tools (Valin and Skoglund, 2019; Okonkwo & Ade-Ibijola, 2021).

Data and learning analytics – These are AI technologies used in tracking students' progress such as data reporting, retention analytic, data mining, and sentiment analysis applications (Algami, 2016; Bodily & Verbert, 2017; Sledgianowski, 2017). Deep learning algorithms are applied to create these tools. These systems have the potential to analysing data from different sources to provide insight about student learning progress (Aldowah et al., 2019). It is very important to track students learning progress to determine where and when they need assistance. Educators use this system to improve student learning experiences (Mahendra, 2023).

Assessment tools – These are AI technologies used to test and assess student performances such as automated essay scoring, chatbot system, and speech recognition applications (Okonkwo and Ade-Ibijola, 2022; Almusharraf & Alotaibi, 2023). Using modern assessment algorithms and AI-powered adaptive learning systems, instructors may acquire a better knowledge of how their students perform in class (Grivokostopoulou et al., 2017; Mahendra, 2023).

Management tools – These are AI-powered tools used to manage various activities in higher education. A comprehensive and user-friendly learning management system is the foundation of a high-quality education. AI is extensively used in many LMS to assist students in tracking their progress and remaining focused (Mahendra, 2023). Also, administrative tasks such management of data set can be achieve with the use of AI technologies (Okonkwo and Ade-Ibijola, 2022).

Academic research tools – These are AI-powered tools used to assist academic research process. Nowadays, several colleges use AI to direct their academic research. It aids researchers in locating pertinent information and ideas that might enhance their work

(Mahendra, 2023; Burger et al., 2023). Some of AI research tools include ChatGPT, Quillbot and many others (Eke, 2023, Yan, 2023).

Student learning experience in Higher Education

The student learning experience comprises the complete process of knowledge acquisition, skills, and competences through educational activities (Guo et al., 2020). It emphasizes on how students interact with the subject, connect with instructors and peers, and enhance their comprehension and talents. The student learning experience in higher education is a multidimensional journey that goes beyond the classroom. It includes engaging instructional techniques, supportive faculty-student interactions, access to resources and support services, and a sense of belonging (Kahu and Nelson, 2018). Higher education institutions may help students develop into lifelong learners, critical thinkers, and well-rounded people ready for tomorrow's challenges and possibilities by concentrating on and enhancing the student learning experience.

Academic performance

Academic performance refers to the assessment of student achievement in various learning subjects such as classroom activities, assignments, exams, and other forms of assessment. It is a measurement of the level of knowledge obtained in any field of study using a standard point. A variety of standardised scores are used to obtain this measurement. It entails meeting the set objectives of a module or course that the student attempted, as expressed in the grades obtained in all assessments (Lamas, 2015). The goal of academic performance is to fulfil the educational objective of learning. This involves passing through a defined procedure or curriculum of learning that changes from one state to another. Academic achievement is affected by a variety of variables, including intellectual capacity, interests, personality, skills, motivation, self-esteem, and study habits, as well as the teacher-student relationship (Lamas, 2015). Student academic performance is impacted by stress and their level of social media use, such as Facebook (Ainin nete al., 2015; Talaue et al., 2018; Frazier et al., 2019). It is crucial to establish the learning objectives and teaching requirements, such as the learning environment, the educator's subject matter expertise, and the assessment criteria, before determining the students' academic performance.

Learning motivation

Motivation is an attitude toward learning that influences whether a learner will give up or persevere, as well as how thoughtfully they will reflect on their learning. Motivation encourages critical reasoning and creativity (Chuter, 2020). Martín-Núñez et al. (2023) concluded that there is a meaningful relationship between learning motivation and AI learning, which creates opportunities for higher education institutions and students. The use of AI for teaching and learning can motivated and improve students learning capabilities (Okonkwo and Abejide, 2021; Chui et al., 2022).

Learning anxiety

Learning anxiety occurs when a student develops a fearful attitude toward a new method of learning, believing that it will be difficult, that it will change the original norm of learning, or that the student lacks the necessary knowledge to attempt the new system. Van et al., (2019) stated that anxiety is naturally exist when using AI system. These disruptive effects of AI use contribute to public concern about AI development. The potentially disruptive implications of AI use raise public concern about AI development (Wang and Wang, 2022). Students always feel anxious when using AI-assisted learning

systems (Abdous, 2019). Wang et al., (2022) concluded that AI learning anxiety has a negative influence on students learning motivation.

Self-efficacy

Self-efficacy is confidence in one's ability to at obtain a desired goal. Students who have a high sense of efficacy are more likely to set ambitious goals for themselves and to be naturally driven. Students' self-efficacy can be positively or negatively influence by the learning strategies and learning environment. Wang and Wang (2022) conclude that self-efficacy influences student's intention to use AI-assisted learning systems. Aldholay et al., (2018) found that self-efficacy does not predict the use of online learning systems.

Cognitive load

Cognitive load involves the quantity of information the student's memory can process at any given time. The cognitive theory is useful for teaching and learning purposes because it aids in managing the learning workload assigned to students so that they can efficiently integrate the contents into their memory storage. Some design factors incorporated into AI technologies may cause a rise in cognitive load (Skulmowski and Xu, 2022). Adaptive learning technologies aim to tailor learning material and learning paths to avoid difficulties, reduce cognitive load, and improve student academic efficiency (Bajaj and Sharma, 2018).

The gap

The purpose of this study is to evaluate the performance and experience of the students learning with AI systems. According to Hwang et al. (2020), rather than focusing on the efficiency of AI systems, it would be more appropriate to assess how AI-supported learning systems affect students' performance and experience. However, academic performance remains a concern for students in higher education (Laguador and Dotong, 2020). There is an issue, say Klemen and Chirikov (2015), in that we still do not fully understand what students go through after they enrolled in higher education. Furthermore, it is unclear what effects using AI algorithms has on activities related to higher education (Ouyang et al., 2022). Investigating the effects of AI on contemporary education is necessary (Martn-Nez et al., 2023). Thus, this study intends to address this gap.

Research method

The goal of this research is to evaluate the performance and learning experience of higher education students learning with AI systems. It is therefore crucial to collect quantifiable data from the participants. To get the necessary quantitative data, the use of AI systems for teaching and learning purposes was explored through a survey; consequently, the positivist research paradigm was used. A questionnaire was employed as a data collection instrument to obtain self-determined data from participants without the researcher's influence.

The instrument of data collection

The questionnaire was divided into four sections, each of which contains closed-ended questions with a five-point Likert scale (1–5: 1—strongly disagree and 5—strongly agree). The sections of the questionnaire are explained below.

Participant's profile – this section collects the personal information of the participants.

Use of AI systems – this section investigates participants' level of knowledge of AI-supported systems and their uses in education.

Performance and Learning Experience – this section examines the extent to which the use of AI systems impact the performance and learning experience of higher education students.

The questionnaire underwent a pilot test to ensure that it met the research objectives. All the feedback was considered, and changes were made as a result. Students and staff from higher education were the intended sample population. The population was drawn from three higher education institutions in South Africa, including Eduvos, North-West University, and Walter Sisulu University.

The population was chosen using non-probabilistic sampling techniques including purposive and convenience methods. The purposive sampling method entails selecting a target audience based on a specific purpose (Okonkwo et al., 2021). This study evaluated the performance and experience of higher education students learning with AI systems, and the population was drawn from educational institutions. The convenience sampling method allows the researcher to collect data from participants who are easily accessible. There are many higher education institutions in South Africa; three were chosen using the purposive method. Because these institutions have a large number of students and staff, it is difficult for the researcher to reach all of them except those who are possible; as a result, the convenience method was used to collect the required data from the participants. The questionnaire was distributed using an online method (Google Form). A total of 317 responses were received.

Ethical considerations

This study was approved by the Institutional Ethics Committee (Approved No. FITREC230051). The participants were duly informed about the purpose of the study and the research protocol.

Data analysis

Several statistical analyses were carried out to get reliable results in relation to the study objectives. To describe the frequency and response percentage (%) of the participants, inferential statistics were applied to all research variables. Reliability analysis was conducted to determine the reliability of the measuring items (criteria = 0.60)

A multi-regression analysis was performed to determine the relationship between the use of AI systems (the dependent variable) and the performance and learning experience of the students (the independent variables).

Reliability test

The reliability of the study variables was assessed using Cronbach's alpha coefficient analysis, and the factors were found to be internally consistent ($\alpha > 0.70$). The correlation ratings of all items are likewise the same ($r = 1$), showing a good correlation among the factors. This is possible because the study was carried out in a unique domain—a higher educational context in which participants' perceptions and attitudes are similar. The results of the reliability test are shown in Table 1.

Table 1: Reliability analysis

Research Variables	Cronbach Alpha (α)
Learning performance	0.78
Learning motivation	0.81
Learning anxiety	0.74
Self-efficacy	0.76
Cognitive load	0.76

Survey results

A survey was conducted to obtain the participants perceptions of the use of AI systems for educational purposes in higher education. The survey results are presented below.

- 1) **Participants’ profiles:** In this section the formation of the sample population is described covering gender, age group, and status (students or staff). See Table 2.

Table 2: Participant profiles

Gender			
Male		Female	
168 (53%)		148 (47%)	
Age Group			
15 – 25 (87%)	26 – 35 (7%)	36 – 45 (4%)	46 – 55 (2%)
Status			
Students		staff	
293 (93%)		23 (7%)	

- 2) **Use of AI Systems** – 88% of the participants agreed that they have good knowledge of AI systems, 5% disagreed, and 7% were neutral. Concerning the use of AI systems for educational purposes, 92% agreed and 8% stood on neutral. In terms of the purpose of using AI systems, participants are allowed to indicate several areas where they have used or are using AI systems. All the participants agreed that they are using the systems for learning and other activities including teaching (30%), research (84%), project (33%), and assessment (17%).

- 3) **Performance and Learning Experience:** To evaluate the performance and learning experience of students using AI systems for learning purposes, five factors were identified and investigated. The results obtained are presented below.

Learning performance – this factor investigates how use AI systems helps students to accomplish their educational goals. Three variables were used to measure this including:

- a) The use of AI-supported systems provides me with more understanding of the module content – 85% of participants agreed, 5% disagreed and 10% were neutral.
- b) The use of AI helps me to successfully complete my assignments/projects – 80% agreed, 11% disagreed, and 9% were neutral.
- c) AI-supported systems provide an individualised learning experience – 76% agreed, 13% disagreed, and 11% were indeterminate.

Learning motivation – this factor examines the extent to which the use of AI systems encourages, helps, and provides adequate orientation towards learning. Three variables were used to measure this including:

- a) The use of AI-supported systems encourages me to learn – 78% of the participants agreed, 17% disagreed, and 5% were indeterminate.

- b) The use of AI-supported systems provides adequate orientation towards learning – 73% of the participants agreed, 15% disagreed., and 12% were neutral.
- c) AI-supported systems help me achieve my learning goals – 71% of the participants agreed, 13% disagreed, and 16% were indeterminate.

Learning anxiety – this factor examines the extent to which the participants are afraid of using AI systems. Three variables were used to measure this including:

- a) I am afraid of using AI-supported learning tools – 32% of the participants agreed, 60% disagreed, and 8% were neutral.
- b) I perceived the use of AI-supported systems as difficult – 23% of participants agreed, 62% disagreed, and 15 were neutral.
- c) I fear that learning something new may take me away from my original norms – 22% of the participants agreed, 61% disagreed, and 17% were indeterminate.

Self-efficacy – this factor investigates to determine if the participants have the required knowledge, abilities, and skills to use AI systems. Three variables were used to measure this including:

- a) I have the required knowledge to use AI-supported learning tools – 83% of the participants agreed, 9% disagreed, and 8% were neutral.
- b) I have ability to perform well with the use of AI-supported learning systems – 68% of the participants agreed, 21% disagreed, and 11% were neutral.
- c) I can easily learn skills by observing others - 82% of participants agreed, 8% disagreed, and 10% were neutral.

Cognitive load – this factor examines the workload place on the participants working memory while using AI systems.

- a) AI-supported tools overload my working memory and make my learning slow or ineffective – 34% of the participants agreed, 55% disagreed, and 11% were indeterminate.
- b) AI-supported learning systems provide explicit guidance as well as practice and feedback – 62% of the participants agreed, 21% disagreed, 17% were neutral.
- c) AI-supported learning systems discover elements of what I need to learn – 58% of the participants agreed, 27% disagreed, and 15% were neutral.

Multi linear regression analysis

To measure the relationship between the use of AI systems and performance and learning experience, a multi regression analysis was conducted. The use of AI systems was considered as dependent variable and the identified factors (learning performance, learning motivation, learning anxiety, self-efficacy, and cognitive load) were the independent variables. The results are displayed in Table 3.

Table 3: Multi linear regression analysis

Coefficients							
Model	B	Std. Error	Beta	t	Sig.	Tolerance	VIF
(Constant)	3.187	.126		25.939	.000		
Learning performance	.098	.028	.124	3.990	.000	.786	1.272
Learning Motivation	.074	.030	.077	2.442	.015	.762	1.313
Learning anxiety	.048	.029	.047	1.565	.118	.821	1.218
Self-efficacy	-.008	.026	-.010	-.316	.752	.790	1.265
Cognitive load	-.101	.029	-.072	-3.718	.012	.758	1.297

Interpretations of the results

This study aims to evaluate the performance and learning experiences of higher education students learning with AI systems. From a previous study, five factors were identified and investigated (Hwang et al., 2020). The required quantitative data was obtained from 3 higher education institutions in South Africa located in 3 different provinces including Gauteng (Eduvos), North West (North West University), and Eastern Cape (Walter Sisulu University). The data was through extracted completely, statistically examined, and results produced.

The sample population for this study consisted of 53% males and 47% females. This suggests that the gender components (male and female) are fairly balanced. AI systems are designed and developed to be used for educational purposes and may be adopted and utilised by anyone, regardless of gender (Okonkwo et al., 2019). This study used different age groups ranging from 15 to 55, and all age groups participated in varying proportions.

The results showed that most of the participants were between the ages of 15 and 25. It suggests that the majority of the participants were students. This is encouraging because student perceptions of the use of AI systems are required to achieve the study goals. Students and faculty were among those who took part. This is possible because performance and learning experiences are created within an institutional context that includes both students and faculty.

The findings revealed that over 80% of the participants have good knowledge of what AI systems are, and overwhelmingly 92% have used them for various educational activities including teaching, learning, research, assessments, assignments, and projects. The result is possible because AI systems are highly exposed, adopted, and used in higher educational environments. For example, Microsoft Teams is being used for lecturing and meeting purposes. This implies that the responses obtained are from people with good knowledge of the applications of AI-supported systems in education.

Performance and Learning Experiences: This study evaluated the performance and learning experiences of students learning with AI systems based on five factors including student learning performance, learning motivation, learning anxiety, self-efficacy, and cognitive load.

Considering learning performance, the study revealed that the use of AI-supported systems in education has significant impact on students' performance and learning experiences by offering quality and enriched content, personalised learning experiences, and helps students to complete their academic activities such as assignments and projects

towards achieving good academic outcomes. This finding is consistent with a research report which stated that the use of AI systems enhances student learning experiences (Alam, 2021).

Regarding learning motivation, the study showed that >70% of the participants totally agreed that the use of AI systems encourages them to learn, provides adequate orientation towards learning, and helps them achieve their learning goals. This suggests that incorporating AI systems into educational settings increases students' eagerness to participate in the creation of their learning experiences and accomplishments. Adequate use of AI systems in education can foster intrinsic motivation and a love of learning. This finding compares well with the conclusions of several studies that there is a relationship between learning motivation and AI systems (Martín-Núñez et al., 2023) and use of AI systems can motivate and improves learning capabilities (Okonkwo and Abejide, 2021; Chui et al., 2022).

Reflecting on the learning anxiety, the study found that > 60% of the participants agreed that the use of AI systems is not difficult, and they are not afraid to use them. This possible because people have accepted to live with AI systems especially after COVID-19 pandemic (Okonkwo et al., 2022). The results indicate that the design of AI systems is simple and can easily be used by students and educators. In addition, the participants are not afraid of the technological shifts and disruptions AI systems may cause in the education setting. This finding contradicts the conclusion of Abdous (2019), who stated that students always feel anxious when using AI-assisted learning systems.

Concerning self-efficacy, > 80% agreed that they have required skills to use AI systems for teaching and learning purposes and they can easily learn from observing others. The integration of AI technologies in education has made the stakeholders involved in teaching and learning to acquire the necessary skills to use the technologies. This result is consistent with the findings of (Wang and Wang, 2022).

Regarding cognitive load, > 55% of the participants agreed that AI systems help their working memory, provide explicit guidance, and feedback, and aid them in discovering updated content to learn. The use of AI systems provides automation of processes that helps manage the workload of working memory. AI technologies enable students and educators to complete various tasks on time. This result agrees with the conclusion of Bajaj and Sharma (2018) that the use of AI technology reduces cognitive load and disagrees with Skulmowski and Xu (2022), who stated that the use of AI technology may increase cognitive load.

A multiple linear regression analysis was performed to determine the relationship between the use of AI systems and students' learning performance and experience. Considering the significant criteria, $R^2 = 32.4\%$ and $p < 0.05$. According to Ellis and Steyn (2003), the criterion for practically significant results is a p-value < 0.05 . Three areas where the use of AI systems has effects on students' performance and learning experience, including learning performance, learning motivation, and cognitive load, have p-values less than 0.05. The results indicate that the use of AI systems in education has a practically significant impact on higher education students by helping them attain higher academic achievement, providing encouragement to learn, and improving their cognitive capabilities. The findings explained that the use of AI systems in teaching and

learning processes has the potential to improve educational systems, especially in aspects of academic performance and learning experience.

Overall, the use of AI systems in education has a significant impact on the performance and learning experience of higher education students by providing quality content and personalised learning that can motivate students to improve their learning capabilities, acquire more skills, and reduce the workload of their working memory.

Implication of the study

This study is unique within the context of the research. It determines students' performances and learning experiences while using AI systems for their studies. A few research has been conducted in this area, and as a result, it adds to academic databases knowledge about the topic under study. The study established that the use of AI systems in education improves learning performance, learning motivation, and cognitive load, which in turn enhance the academic performance and learning experience of higher education students. The stakeholders involved in the design and development of AI systems should ensure that they incorporate the features that enable the improvement of these factors to advance the learning process in higher education.

Conclusions, limitations, and future works

This study evaluates the performance and learning experience of students learning with AI systems. A quantitative research approach was employed through a survey that included three higher educational institutions from three different provinces. Five factors were identified and investigated. Several statistical analyses were performed on the collected data to obtain the required results. The inferential statistics revealed that a large number of the participants have good knowledge of AI technologies and their applications in education, including teaching, learning, research, assignments, and projects. Furthermore, the study shows that the use of AI systems in teaching and learning has a significant impact on improving student academic performance, increasing learning motivation, and reducing cognitive load. A multilinear regression analysis confirmed that the use of AI in education has practically significant capability to predict students' performance and learning experience in higher education. The study offers additional insight into students' levels of expertise when utilising AI systems for teaching and learning processes and may aid higher education institutions in evaluating how and which aspects of technology deployment for educational purposes may be improved.

Limitations and future works

This study focuses on higher education; other levels of education may be investigated in the future. Second, using a cross-sectional design restricts the study to a single viewpoint. Longitudinal study designs could be used in future research to account for time differences.

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The importance of Learner Management Systems in enhancing knowledge management within Higher Education Institutions

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Abstract

Digital transformation is important in disseminating information and implementing good practices. This shows that online learning learner management systems can enhance knowledge management within Higher Education Institutions (HEIs). When knowledge is effectively shared and utilised it becomes a critical element that enables HEIs to be innovative and sustainable. Additionally, it is essential to manage and share knowledge for the growth of HEIs. Knowledge management is a tool that can assist organisations with gaining a competitive advantage. It is an improvement, survival, and growth strategic resource. The Learning Management System (LMS) of the 21st century is its ability to capture and curate the best knowledge from within the organisation. This study's main focus is to gain an understanding of the importance of LMS in enhancing knowledge management in HEIs. This is a conceptual paper where literature on LMS enhancing knowledge management will be reviewed. The findings of this study will be beneficial for HEIs in understanding how they can use the LMS in enhancing their knowledge management as knowledge management plays a vital role in creating a competitive advantage for HEIs.

Keywords: Knowledge management, higher education institutions, learner management system

Introduction

The volume of information is increasing drastically all over the world as the world enters the knowledge economy (Khoa, Ha, Nguyen, & Bich, 2020). Higher Education Institutions (HEIs) need to promote and facilitate sustainability in order to remain competitive (Braun & Spielmann, (2020). According to Kanwal, Nunes, & Arif, (2019), when knowledge is effectively shared and utilised it becomes a critical element that enables HEIs to be innovative and sustainable. This stresses the importance of Knowledge Management (KM) in HEIs. Furthermore, digital transformation is important in disseminating information and implementing good practices (Di Vaio, Palladino, Pezzi, and Kalisz, 2021). However, several challenges present themselves as HEIs try to adapt

to the Fourth Industrial Revolution. The Covid-19 pandemic added to the challenges faced by HEIs. It has not only affected HEIs internationally but has also brought several challenges to the higher education communities in South Africa (Bhagat & Kim, 2020). To face these challenges, HIEs need to realise that Knowledge is a strategic resource (Kassaneh, Bolisani, & Cegarra-Navarro, 2021).

The Fourth Industrial Revolution (4IR) has led to a need for people with creative ideas and knowledge that is extraordinary. This has resulted in the emergence of emerging technologies. Emerging technologies can be defined as those technologies that have the potential to gain social relevance within the next decade (Stahl, 2011). This is evident as some authors have highlighted how the emerging technologies used in supporting creativity have increased Li, Kim & Palkar (2022).

Technological advancements and 4IR have enabled an environment where learning is more student-focused (Costley, Southam, Bailey & Haji, 2022). Many technology solutions are used by educational institutions to make knowledge available, with the majority focusing on the establishment of a virtual learning environment (VLE), often known as a learning management system (LMS). VLEs are open systems that allow users and instructors to connect and share information while also offering access to a wide range of resources stored on the system AbuShawar, B.A. & Al-Sadi, J.A. (2010). The usage of technology-based Learning Management Systems (LMS) and online learning is expanding in higher education.

Success in HEIs depends on the knowledge generated, exchanged, and stored by all participants, thereby enhancing the efficiency of the system as a whole (Rowley, 2000). According to Al-Kurdi, Alshurideh, Salloum, Obeidat, & Al-dweeri (2020), the HEIs mission and vision are directed by knowledge creation and dissemination. The authors added that there is a lack of KM application in HEIs when comparing HEIs to other sectors. One of the contributing factors could be that the HEIs do not apply KM programs that are coherent. Therefore, the study seeks to understand the importance of LMS in enhancing KM in HEIs.

Knowledge management

Although the foundations of knowledge management can be traced back to the previous century, KM only became established in the 1990s (Ishak & Mansor 2020). Numerous academics and professionals have since realized that firms must continually develop, capture, and reuse knowledge to stay competitive (Razmerita, Wren & Jain, 2016). To put it simply, "KM" is an acronym for "explicit strategies, tools, and practices, applied by management, which seek to make knowledge a resource for the organization" Razmerita, L., Wren. G. & Jain L. (2016). KM is characterized in this context as "enabling organizational learning and supporting activities such as knowledge acquisition, generation, sharing, and use" AbuShawar, B.A. & Al-Sadi, J.A. (2010). There have been numerous approaches to assisting knowledge acquisition by focusing on a certain type of learners and implementing a business model from the information and communication areas (Kurusu, Matsumoto, Kashima & Akiyosh, 2014).

KM promotes the distribution, transfer, use and creation of knowledge and it plays an important role in the improvement of the decision processes (Moscoso-Zea Castro, Paredes-Gualtor, & Luján-Mora. 2019). Furthermore, knowledge management can strengthen the position of an HEI. As information-based capital is a significant driver of

value creation and competitiveness in the knowledge and digital economies, businesses must manage knowledge work. Mahdi, Nassar, & Almsafir (2019), highlighted the importance of the acquisition of knowledge and being able to use it in an effective manner in order to gain a sustainable competitive advantage. Businesses often employ ICT, also known as knowledge technologies, enterprise systems, and KM systems, to aid in the management of knowledge processes. Organizations have invested a lot of time, money, and other resources in various technologies to help with their KM activities, some of which are sometimes inappropriate (Razmerita, Wren & Jain, 2016).

Farnese, Barbieri, Chirumbolo & Patriotta (2019) put forth the dynamic theory of organizational knowledge generation, the significance of knowledge and its management has been well-established for many years. Knowledge is now increasingly regarded as being essential for firms to be innovative, competitive, and sustainable (Poonkothai, 2016). Nunes, Kanwal & Arif (2017) postulate that through knowledge collection, production, refinement, storage, transfer, sharing, and utilization, KM is intended to maximize the organization's knowledge assets and ensure more effective knowledge practices, improved organizational behavior, and higher performance. The term is described as "the effective learning processes associated with exploration, exploitation, and sharing of human knowledge (tacit and explicit) that use appropriate technology and cultural environments to enhance an organization's intellectual capital and performance" (Dhamdhare, 2015).

Knowledge management in HEIs

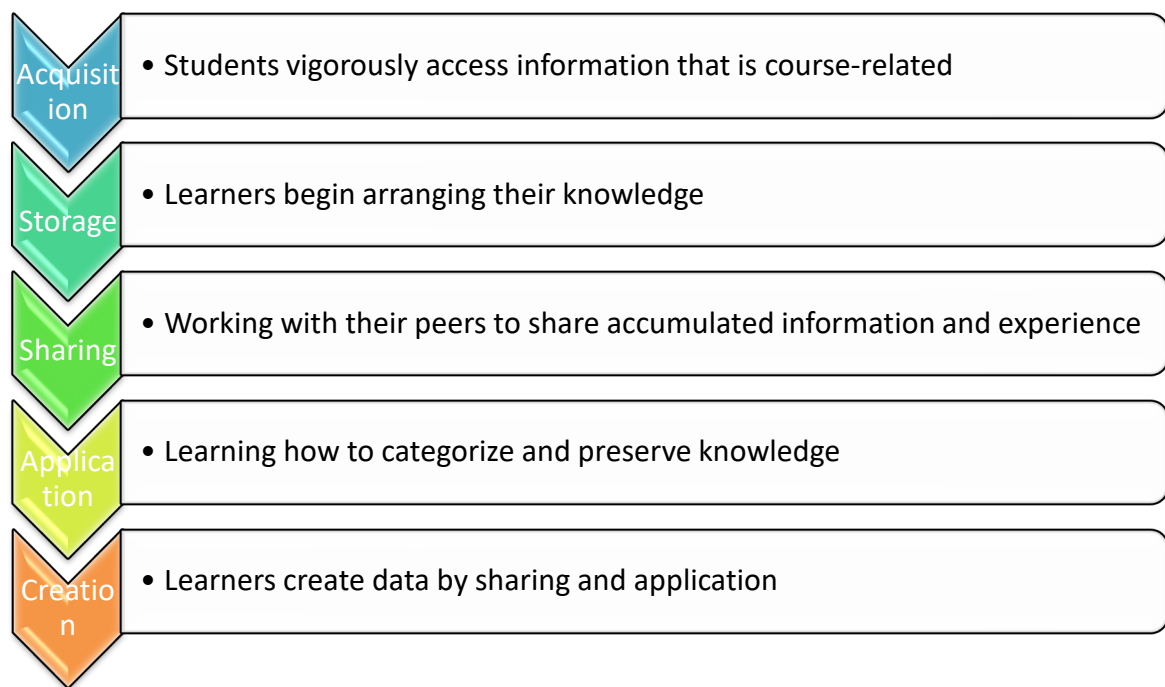
According to (Nunes, Kanwal, & Arif, 2017). KM in the educational connotation is defined as activities that aid the academic institution in developing learning and teaching, research, and administrative functions. KM also promotes knowledge sharing and provides information concerning decision-making processes. Tacit and explicit knowledge can be distinguished as KM (King, 2009). People employ their explicit and tacit knowledge in their particular ways, according to Louw and Venter (2019). Individuals create tacit knowledge on the inside through their experiences and professional actions (Nunes, Kanwal, & Arif, 2017). It exists in their minds and is typically not expressed explicitly (Louw & Venter, 2019). Although it has a multifaceted structure, this structure plays a distinct and important role in a person's organizational success (Koudouovoh, 2014). However, it is hard to access because it is frequently not codified and may not always be simple to articulate (Chugh, 2013), and if it stays in the minds of a small number of people in an organization, it may cause knowledge loss (Chugh, Wibowo, & Grandhi, 2015). To get the most out of their intellectual capital, businesses must therefore develop strategies for turning tacit knowledge into explicit knowledge (Omotayo, 2015). Organizations typically include higher percentages of explicit knowledge in addition to tacit knowledge, which is made up of data that is expressed in formal language and is either technical or academic (Venkitachalam & Busch, 2012). In academic settings, human efforts, which are created through educational and research activities, creativity, and learning, are the primary source of knowledge formation in academic contexts (Dhamdhare, 2015).

Academic and organizational knowledge is produced and internalized by faculty, students, administration, and researchers in HEIs, respectively (Nunes, Kanwal & Arif, 2017). According to Hawkins' study (2000), HEIs considered KM as an assignment to be conducted by librarians only. But this is a reductionist perspective that not only ignores tacit knowledge but also presupposes that all knowledge produced by HEIs is kept in the academic library. This is not the case, and in the current digital information age, this

viewpoint needs to be modified and the prejudices of library professionals set aside (Nunes, Kanwal & Arif, 2017).

In order to propose and investigate new KM frameworks, it is necessary to reconsider meanings, examine outdated paradigms, and investigate new KM players in academia. Few integrative studies have examined KM at academic institutions as a whole, in contrast to the business sector. Therefore, effective research and the implementation of KM in institutes of HEIs are necessary to benefit the faculty and staff, share their knowledge, and manage it (Toro & Joshi, 2013). Although HEIs produce knowledge through their academic and administrative operations, they still struggle to leverage explicit and tacit knowledge as a centralized integrated resource to enhance knowledge sharing and efficient decision-making (Kumar, 2015). In developing economies, KM research is still emerging (Asrar-ul-Haq & Anwar, 2016; Zhao et al., 2022).

In academic institutions, the knowledge management process consists of five stages: (Chen & Huang, 2010; Barley *et al.*, 2018; Sahibzada et al., 2021; Zhao et al., 2022):



Hantoobi, Wahdan, Salloum & Shaalan (2021) agree with the statement that the knowledge management process consists of five stages as they have highlighted the knowledge management process to include the following:

- Knowledge creation: this is when one acquires information and ideas so that tacit knowledge can be formed.
- Knowledge sharing: the flow of the created knowledge from one person to another with the aim of sharing and transferring expertise for the development of new knowledge.
- Knowledge capture: converting clear knowledge to tacit knowledge and vice versa.
- Knowledge storage: keeping the knowledge so it can later on be retrieved.
- Knowledge application: using the knowledge through LMS to gain a competitive edge.

- Knowledge evaluation: ensuring the benefits of the captured knowledge to the students.

Learners may explore materials and share their experiences with others without being restricted by a classroom. They can also use the wireless network to customise the organization of knowledge and save it. Self-learning allows students to improve their problem-solving abilities (Chen & Huang, 2010).

Discussion

Knowledge management, from the perspective of information technology (IT) professionals, is the use of knowledge by computers; this incorporates several computer branches, such as data mining, question-answering systems, and natural web interfaces. KM is "an emerging area of IT practice that developed from the disciplines of computer science, library information science, organizational psychology, and management," according to AbuShawar & Al-Sadi (2010). Abubakar, Elrehail, Alatailat, & Elçi (2019). guarantee that the growth in the IT sector helps KM by expanding storage capabilities and updating information. As a result, the demand for knowledge management has increased expanding beyond the corporate world to include a variety of fields like information sciences, cognitive sciences, strategic management, document management, and organization sciences. The increased use of information technology, as well as the increase in internet speed and usage, all contribute to the transition away from tightly structured prescribed learning paradigms and toward informal and collaborative information and knowledge sharing (Ras & Rech, 2000). This opens the door for the implementation of innovative remote learning paradigms such as open learning, blended learning, and e-learning. A tree can be considered as the root of these new trends, which is distant learning, and the branches, which are diverse paradigms. Each has a unique set of functions and intended users, but they all share the ambition to make learning available wherever and whenever it is needed (AbuShawar & Al-Sadi, 2010).

The utilisation of LMS in administering knowledge management techniques will enable HEIs to achieve a competitive advantage and be a preferred institution for academic growth (London & Hall, 2011). An LMS is an e-Learning platform that assists lecturers in the management of their courses (Ouadoud, Nejjari, Chkouri, & El-Kadiri, 2017). The e-learning approach is the utilisation of computers and online websites for communication and knowledge delivery (AbuShawar & Al-Sadi, 2010). One of the most commonly utilised LMS is the Visual, Aural, Read/Write VARK model (Rani, Srivastava & Vyas, 2016). The VARK model main focus is on the delivery of information and it requires no skill or intelligence. According to Othman & Amiruddin, (2010) VARK is a great model to facilitate personalisation where learners are able to determine their learning boundaries based on their educational needs.

Making the most of hidden knowledge through the use of LMS

There are several steps that organisations can follow when they want to make the most of their organisation's hidden knowledge (Cloke, 2017). These include:

Creating a space for sharing knowledge where you link communication channels to the LMS. The LMS has various features which assist in facilitating learning and these features include quizzes, digital teaching materials tests, class formation assignments and information sharing which are all done online with the aim of improving the learning

process (Taufiqurrochman, Muslimin, Rofiki & Abah, 2020). LMS creates space for information exchange (Khan, Nabi, Khojah & Tahir, 2020).

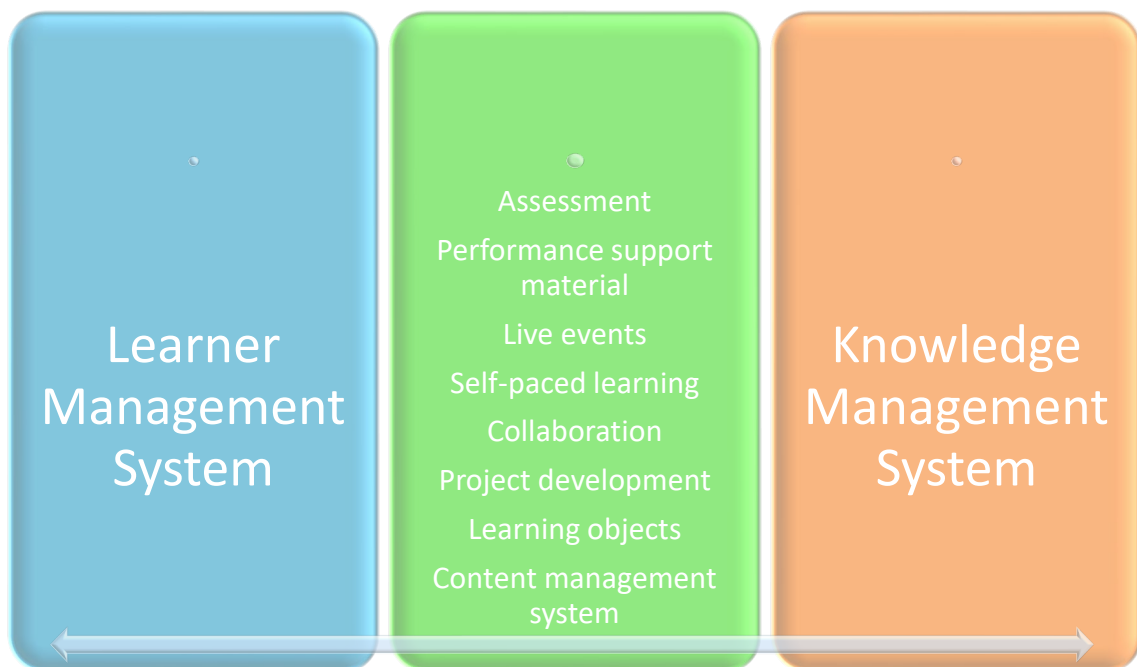
Intellectual capital is the organisations value-creation assets in the form of knowledge and is based on the organisations knowledge and experience (Nisar, Haider, Ali, Jamshed, Ryu & Gill, 2021). Building your intellectual capital through the LMS makes it simple to find people with real expertise who can assist. Once experts are identified make people find them and establish an area for the experts on the platform. This acts as an incentive for other learners as if they know that they can earn the title ‘expert’, they may be more likely to demonstrate their knowledge (Cloke, 2017).

Grow your audience and get everybody involved (executive management to students). Make your learning platform more appealing with aspects such as gamification and offering virtual rewards. According to Bhattacharya & Chaubey, (2019). LMS makes it possible to reach large audiences globally in a short period of time making it a more cost-effective way to grow your audience. Furthermore, the LMS increases access making learning to be more effective and it increases student motivation and involvement (Ridlo, 2021).

HEIs need to understand and realise they will never be finished with making the most of the hidden knowledge because, in an ever-changing world, intellectual capital needs to be constantly maintained and updated (Cloke, 2017).

LMS features that enhance KM

Figure 2 shows the LMS features which assist in enhancing KM.



*Figure 2: LMS and KMS features
Source: Adopted from Qwaider, (2011)*

- Assessments: This is to measure students’ knowledge. LMS through assessments enhances knowledge management since online assessment systems allow for the generation, management and sharing of knowledge (Rafaeli, 2003).

- Performance support materials: These are materials that enhance learning transfer and retention. According to Bielawski (2003), performance support includes coaching and mentoring and online help. These enhance knowledge management as it leads to the transfer of knowledge, sharing of best practices, connecting with experts in the field and having lifelong continuous learning. Furthermore, performance support is the first step towards KM as it puts knowledge and information where it is needed.
- Live events: This enable the students to participate at the same time in a virtual classroom. Live streams allow for sharing of knowledge and the advantage is that these live streams can be recorded to be viewed later on or for anyone who was not able to attend at the time to still get the knowledge that was shared (Lu, Heo & Wigdor, 2018).
- Self-paced learning: learners are able to pace themselves and complete tasks individually at their own time and own pace. Self-paced in most cases is achieved through the use of video technology in learning. According to Palaigeorgiou, & Papadopoulou (2019), video learning increases students' participation and achievement and their interest in learning.
- Collaboration: the virtual communities have needs for knowledge and content exchange. As a result, the new technologies integrated into systems allows for new types of communication and collaboration in the communities. Alshwayat, MacVaugh, & Akbar (2021) mentioned that collaborative engagements are vital as they aid in creating and sharing new knowledge.
- Project development: Refers to the projects developed by students. The LMS allows for such projects to be scheduled and implemented on time.
- Learning objects: the discrete chunks of reusable online learning materials. The creation of the central repository which contains reusable learning objects using objected oriented design through international standards serves LMS and KN needs (Qwaider, 2011).
- Content management system: A web application that makes it possible to edit, add and remove web pages without having the technical expertise (Patel, Mittal & Awadhiya, 2019).

Conclusion

The information-based economy of the twenty-first century is focused on sharing, organizing, managing, and creating information. This suggests that in the future, competition will be driven by the knowledge revolution. As society evolves, so is the importance of teaching students how to apply their knowledge. Integrating knowledge management is the most effective way for improved student knowledge management and problem-solving skills. Learners can now access digital learning websites at any time and from any location, thanks to advancements in wireless technology. In the wave of digital learning, mobile learning is capturing more and more attention. The evolving usage of knowledge management is critical for improving problem-solving skills. This was a conceptual paper. It would be recommended that for future research an empirical study must be conducted at HEIs to understand how they are using LMS to enhance their knowledge management.

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Preparing first year programming students for future studies by mitigating source code plagiarism

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Abstract

Towards the end of the Covid-19 pandemic, the academic world prepared to move out of emergency remote learning mode – to a new normal. With contact classes restricted, students were left to their own devices, conditions not conducive for learning. This is especially true for students who prefer contact, rely on university infrastructure, and chose to attend a contact university for this purpose. Assessments are having a high impact on learning, and online assessment, a pivotal Covid-19 tool, is making it impossible to ensure that students do their own work. In addition, the context of teaching an introductory programming course to two groups of students; those with a thorough background in programming – from school, and those with no background. Source code plagiarism becomes an academic challenge because it is running rampant among students under these conditions. Especially students with no programming background, are vulnerable. The intention is to use the identification of source code plagiarism as an opportunity to teach students about plagiarism, in the context of programming. This process already started in 2021 and continued in 2022. Making sense of how to guide students regarding source code plagiarism may be valuable in the context of a new normal – to ensure that students are obtaining the knowledge and skills they need to build onto in subsequent subject modules, necessary to reach the outcomes of a computing course. The 2022 first semester offering on introduction to programming in Python, offered on as a first-year university bachelor's degree level at an institution in South Africa, is reflected upon. It is done from the dual perspective of the lecturer, and the students who were caught in the act of plagiarising scripts. In addition, this data is compared to that of 2021. To facilitate the identification of source code plagiarism, and make sense regarding why they are copying code, students identified were encouraged to start a conversation with the lecturer. Comparing the conversations of 2022 to those of 2021, to obtain findings which will guide future offerings.

Keywords: Source code plagiarism, Introductory programming, Teaching and learning to code

Introduction

Computing students at the start of their academic career needs to learn how to code, a skill that needs time and diligence to obtain, but a crucial one when working in the computer industry. When such students revert to source code plagiarism, they do not learn the skill, and the purpose of doing the subject module is defeated. In addition, to copy and paste programming code is easy to do, a lightning quick action, and difficult to detect (Karnalim, 2017).

The university in question comprises three campuses and an Open Distance Learning Unit. The subject module is offered across six classes, with a total of more than 1,000 students. This paper centres on a specific class that enrolled 239 students. The student bodies of these entities significantly vary in terms of computing background and access to resources. The first semester subject module, which is the focus of this paper, addresses

three distinct components: computing concepts, practical work in Microsoft Excel, and an introduction to programming – with the latter scrutinised in this paper. Covid-19 emerged in South Africa in March 2020 and the university transitioned to emergency remote teaching and learning, which allowed first-year students to experience contact classes only during the first quarter of the year. It is noteworthy that the researcher was not involved in teaching the Introduction to Programming course at that time. To address the Covid-19 restrictions in 2021 and facilitate programming newcomers' engagement with instructors and tutors, multiple strategies were employed. These included conducting a weekly theory class via the Zoom platform, holding a practical class on the Zoom application to demonstrate taught concepts, hosting physical practical sessions in a computer laboratory, and scheduling tutor-led question and answer sessions on Zoom for a once-a-week at midnight and noon. Telegram groups were also established to provide ongoing support, complementing the eFundi Learning Management System platform. eFundi provided access to slides, videos, a customized textbook, and all assessments. Due to Covid-19 venue capacity limits, students were encouraged to attend practical sessions only if they had a specific need for contact classes. Although Covid-19 restrictions were lifted in 2022, it only occurred toward midyear, and therefore Covid-19 venue capacity limits were still in place during the first semester. With a much larger student component in 2022, an end of semester figure of 216 compared to 179 in 2021, and the exact same capacity limitations, it did place much pressure on the lecturer and students. These circumstances created opportunities for students to utilise source code plagiarism to support their goal of passing the module, as was already established in 2021. The aim of this paper is to establish whether the problem is growing.

Subsequent sections address the literature applicable to this study, the research design, analysis of the data, the discussion of the findings, and lastly concluding remarks.

Literature review

The literature with regards to Python and its assessment is discussed, along with source code plagiarism (SCP), a software tool to detect SCP, and the interpretivist approach applicable to this study.

Python and its assessment

As indicated by the description “*Introduction to Python programming*”, Python 3 is employed as the programming language for instruction, utilizing the integrated program development environment (IDLE) that accompanies the Python installation (Lambert, 2018). The Python Shell within IDLE offers an interactive environment for running Python expressions, while Notepad++ serves as an additional editor. The teaching approach involves guiding students to use the Windows command-line for Python commands.

However, due to the absence of an automation tool such as CodeGrade, the assessment of scripts is time-consuming, necessitating assistants (senior students) for the evaluation of practical coding assignments and tests (Helminen & Malmi, 2010). Plagiarism detection proves challenging as students attempt to disguise copied code, leading to difficulty in identifying culprits among the large student population. The shift to online and continuous assessment during the Covid-19 pandemic posed further challenges, leaving students to self-regulate their learning (Miller, Visser, & Staub, 2005).

Source code plagiarism and its detection

The plagiarism of text remains a persistent concern in academic settings, with widely used tools such as Turnitin, Grammarly, and Duplichecker effectively addressing issues in academic writing (Bhosale, 2022). However, these tools are not designed to detect source code plagiarism (SCP), requiring the utilization of specific alternatives like Measure of Software Similarity (Moss), Codequiry, and CodeLeaks (Younas, 2021).

Perceptions of code copying can vary based on a programmer's experience, leading to diverse viewpoints on defining SCP. Such discussions often pertain to novice programmers compared to more advanced learners and even beyond the educational sector, as experienced programmers (Cosma & Joy, 2008), as described below:

1. For students learning to code, copying code to solve elementary problems can undermine the purpose of learning. In this context, it is worth noting that while students often begin their learning journey with provided material such as a text book, code snippet demonstrations, and example programs – using such provided material is not seen as plagiarism, distinct from "*unintentional or purposeful plagiarism*" involving the use of external material (Joy, Cosma, Yau, & Sinclair, 2010).
2. In contrast, a more experienced programmer may devise complex scripts to address intricate issues without directly copying existing code. However, they might utilize code snippets from peers, colleagues, books, or the Internet to ensure the script aligns with specifications. This practice might apply to educational or professional contexts.

As a SCP detection (SCPD) tool, Moss was developed by Stanford University (Schleimer, Wilkerson, & Aiken, 2003). It was employed by a lecturer at another campus before 2021. After discussions with, and receiving guidance from, the responsible lecturer, the decision was made to utilise Moss for SCPD within the discussed class group since 2021. The selection of the Moss tool was underpinned by two pivotal reasons: its Python compatibility and its freeware nature. Moreover, Moss presents inherent safeguards against cheating; it remains unaffected by whitespace variations, suppresses noise generated by random code, and remains position-independent, thus maintaining its ability to detect copied code despite code reordering (Aiken, 2000). Notably, even when variables are renamed, Moss remains undeterred. This is important as indicated by the taxonomy developed by Faidhi and Robinson (1987), indicating comment, whitespace, and delimiter modification, identifier renaming, and component declaration relocation as low level plagiarism attacks – typically performed by novice programmers. Research done by Karnalim (2017) confirmed that top plagiarism attacks include modifying comments and whitespaces, modifying identifier names, incorporating useless arguments on syntax forms, listing dummy instructions, and re-ordering loosely-coupled instruction. It is important to acknowledge that Moss does not autonomously identify SCP. While it can identify program similarities, it cannot ascertain the underlying intent behind similar code pairs; was there collusive activity or not (Karnalim & Chivers, 2019). The determination of deliberate collusion still necessitates human scrutiny. Following Moss's highlighted code portions, human evaluators must determine the presence of plagiarism. However, even adhering to this guideline, the process is not always straightforward. Nonetheless, Moss significantly supports educators by flagging code sections which warrants more in-depth examination, creating awareness of potential dishonesty. It is crucial to emphasize that the effective usage of Moss is dependent on human involvement and reliance solely on similarity scores would misrepresent the utility of Moss. While Moss generated scores are valuable for gauging the number of matches among various

script pairs and for highlighting outliers with an unusually high number of matching lines or percentage similarities, they alone do not validate plagiarism claims (Aiken, 2000).

Underlying paradigm

A research endeavour conducted by Schreuders and Whiteacre (2014) delved into the sharing of code within engineering students, adopting a social networking standpoint and relying on quantitative data. In contrast, this underlying study adopts an interpretivist perspective and leans on qualitative data, offering a distinct worldview (Myers, 1997). The research conducted by Klein and Myers (1999) in which the Principle of the Hermeneutic Circle underpins six other principles: Contextualization, Interaction Between the Researchers and the Subjects, Abstraction and Generalization, Dialogical Reasoning, Multiple Interpretations, and Suspicion; was employed to ensure validity.

While the broader study is employing content analysis of conversations between the lecturer and students identified as dishonest as underlying qualitative technique which will be reported on in a future paper, this paper seeks to structure the communication between the instructor and individual students – to make sense of which categories could be identified. Categories include why students started communication with the lecturer, and why they were identified as dishonest, in some cases wrongly so. In essence, the data obtained in 2022, is compared to the introductory study which was conducted in 2021. Questions such as; “Did the situation improve or worsen – from 2021 to 2022?”, and “Was saturation reached in terms of the codes and categories reached?” The aim is to lay the groundwork for future research within a broader context, contributing to a more comprehensive understanding of SCP among students and beyond; including young professionals.

Research design

The design of this study involves all Python assessments of 2022, integrated with those of 2021. Identifying instances of dishonesty involving SCP, entails a step-by-step process: beginning with the identification of SCP cases (assessment and Moss identification), followed by the formation of a subset of these cases (through human intervention), subsequently, students were provided the opportunity to engage in communication with the lecturer concerning their respective cases to establish SCP (Smit, 2022).

Participant selection

This study involved all students in the class identified as dishonest, with a more in-depth focus on participants who chose to interact with the instructor. Upon identifying dishonesty cases, the marks of students in this group were adjusted to reflect their status, and an announcement was posted on eFundi. The information regarding the peer(s) each student shared code with, was included in the announcement in 2021, but omitted in 2022. Students were then invited to start an email conversation (in 2021 Telegram or eFundi Messages were utilised) with the lecturer. Table 1 states the numbers of dishonesty cases associated with each assessment – to illustrate the magnitude of the problem. Slight differences occurred in the breakdown of the work when comparing 2022 with 2021. When comparing these numbers with the number of individual students who were identified as dishonest, it should be considered that a student may be identified to be dishonest in more than one assignment (and even in more than one problem in an assignment, which is not reflected here).

Table 6. Identified cases in 2021 and 2022

2022		2021	
Assessment	Dishonesty cases	Assessment	Dishonesty cases
SU5	42	SU5	0
SU6	76	SU6	25
SU7	82	--	
--		SU7-1	22
--		SU7-2	14
SU8	141	--	
--		SU8-1	43
--		SU8-2	25
SU9	40	--	
Test 2	--	Test 2	3
Test 3	20	Test 3	2
Total	401	Total	134

Dishonesty in assessments

Each assignment focused on a specific concept taught in the corresponding study unit of the week, encompassing two or three problems for which students were required to devise Python script solutions. Successive assignments presupposed the integration of recently acquired concepts with previously covered ones. Penalties were only imposed on scripts that were identified by Moss as similar - and subsequently confirmed by the instructor as involving plagiarism. Instances of dishonesty observed in Python tests were categorized alongside assignments. The identification of instances of SCP is laborious (Karnalim, 2017), and entailed a step-by-step process, which was outlined by Smit (2022).

The steps are summarised below:

- Step 1: Assessment of assignments/tests; with a very limited number of plagiarism cases picked up on.
- Step 2: Moss is employed to list potential cases, displaying similarity percentages and number of lines between scripts.
- Step 3: Each case undergoes meticulous scrutiny (Karnalim & Chivers, 2019) to determine whether a candidate merits classification as dishonest, with the final verdict resting with the instructor.
- Step 4: Students are invited to present their case. In instances where a student effectively persuades the instructor of their independent effort, the marks are reinstated.

Because of time constraints applied to the tests and formal assessments it is more difficult for students to plagiarise code, and therefore not many dishonesty cases were identified.

Analysis of the data

While each assignment or test encompassed multiple problems, with some students displaying dishonesty in only one problem while others were dishonest in all included problems, this information was not recorded. This is because the study's emphasis is on the number of students involved in SCP rather than the count of copied Python scripts.

In 2022 56 email conversations were started. In 2021 this figure was 22; 21 on Telegram, and one on eFundi Messages. It was anticipated that the purpose would be to establish innocence with regards to Moss identifying individuals as being guilty of SCP. The conversations revolved around how it may be possible to be identified by Moss, but not be guilty of SCP. In some cases, the lecturer shared the code snippets of the applicable

code pairs with students – to assist them in explaining why they were highlighted by Moss as colluding.

It should be noted that Assignment SU5 included problems relying on the print statement, and because only the sequence programming structure were covered at the time, students had to rely on hardcoding – to solve the problems. Because of this the lecturer sympathetically looked at these dishonesty cases that was argued by students to be dismissed. Beyond assignment SU5 hardcoding was not imperative, and whenever students reverted to hardcoded scripts, they were allocated a mark of zero and therefore were excluded from the dishonesty.

While making sense of the data, a code table was compiled – in 2021, with the 2022 code table superimposed. Table 2 shows the suggested codes related to the identified descriptions. Refinements based on the 2022 analysis were made to the table resulting from the 2021 analysis. Additions were highlighted in blue, while one omission was ~~erossed-out~~ (both tutors and students were prepared beforehand regarding SCP), indicating that a point of saturation has not been reached yet. The codes were also categorised.

Table 7. Codes and explanations

Category	Description	Code	Description
None	Not identified as having similar code with a peer	--	--
No_SCP	Identified dishonest, as but exempted	XSCP_INST	No SCP, followed assignment instructions
		XSCP_VID	No SCP, followed a video uploaded by the lecturer
		XSCP_TXT	No SCP, used an example from the textbook
		XSCP_CORR	Corroborated story
		XSCP_TUT	No SCP, received help from a tutor in practical class
SCP	Identified as dishonest, not any convincing argument to be exempted	DC_COLL	Collaborate with peer(s)
		DC_HELP	Helped a peer
		DC_ASST	Received assistance from a peer
		DC_YTUB	More than one student copied the same YouTube video/the Internet
		DC_MULT	Multiple cases against a student stack up evidence
		DC_C&P	Copy & paste
		DC_SERR	Peers copy spelling mistakes from one another
		DC_XERR	Peers copy mistakes from one another – a structure not yet taught
		DC_NERR	Peer(s) copy the original author's name

Category – none: when discussing the table, it should be noted that a large group of students' scripts in the 2021 and 2022 classes were never identified by Moss as similar to a peer, not even reflecting a low similarity percentage, or any number of similar lines. Although this category is not the focus of this paper, it should form part of the argument. Some students are serious about the progress of their studies, and they understand that, in order to learn, they need to facilitate their own understanding.

Category – No_SCP: of 56 (22 on Telegram/eFundi Messages) email conversations, 91 (31) assignment dishonesty cases were challenged, and 8 (13) assignment problem marks were re-instated because these students stated arguments that convinced the lecturer of their innocence. Arguments included:

- Using a video supplied by the lecturer <XSCP_VID>, or snippets from the textbook <XSCP_TXT>, or the problem instructions guided the student closely <XSCP_INST >. Where students had more than one case against them, some convinced the lecturer of their innocence on one case, but not another (2021 only).
- Although help received from a tutor was accepted as an excused in 2021, this was not acceptable in 2022, since tutors were explicitly made aware of the fact that they need to be careful when providing assistance <XSCP_TUT>.
- Students corroborated one another's arguments <DC_CORR>.

Regarding Assignment SU5 (2021), students successfully persuaded the lecturer that the identified instances of dishonesty were, in fact, not genuine cases of plagiarism but rather a result of hard coding; and as a result, all marks for this assignment were reinstated. In contrast, in 2022, only a limited number of students managed to persuade the lecturer, leading to only a minor portion of marks being re-instated.

Category – SCP: of the 91 (31) assignment dishonesty cases that were challenged, there were 48 (18) cases where students did start a conversation but could not convince the lecturer of their innocence.

Examples include:

- In contrast to 2021, when no students indicated that they collaborated with one another, although the evidence showed that it did occur, in 2022 there were students who admitted that they worked with a peer towards a solution <DC_COLL>. During both years, in the cases where a number of students were linked to one another, the differences in their marks indicated varied reliance on another.
- Some students did admit that they helped another student <DC_HELP>; and in other cases, students recognised that they received help <DC_ASST>.
- Cases piled up against some students who repeatedly were identified to be dishonest <DC_MULT>. It made it more difficult for a student to convince the lecturer of innocence on any one assignment problem. This occurred in 2021 and 2022.
- Code is not examined for similarities with code extracted from the Internet; however, if two candidates utilized the same source (communicated through YouTube videos), Moss recognizes it as a case of dishonesty <DC_YTUB>. This occurred in 2021 and 2022 (Figure 1).

```

print(" 0      0      0      0 ")
print(" 0      0      0      0 ")
print(" 0      0      0      0 ")
print(" 000      ")

#inputs
name = input("Please enter your name")
radius = float(input("Please enter the radius of the fish tank in cm: "))
height = float(input("Please enter the height of the fish tank in cm: "))

print("Hi "+name+", I will provide you with the amount of water needed to fill you

#Volume of cube
import math

Volume = (4/3)*math.pi*radius**3
print("\n for a cylinder shape: ")

print("The volume of the fish tank is: ",(round(Volume,0)),"m1")
WaterHold = Volume/1000

print("The amount of water that the tank can hold is: ",(round(WaterHold,1)),"1")
print("And one tiny fish needs 1,5l of water in order to survivin the tank")
print("\ndid you know?")
print('')
Feed you fish twice a day.

print(" 0      0      0      0 ")
print(" 0      0      0      0 ")
print(" 0      0      0      0 ")
print(" 00      ")

#inputing the given values
name=input("Please enter your name: ")
FishTank_radius=float(input("Please enter the radius of the fish tank in cm: ")
FishTank_height=float(input("Please enter the height of the fish tank in cm: ")

#Greetings
print("Hi "+name+" ,I will provide you with the amount od water needed to fill

#Computing the volume of the cylinder
import math

Volume = math.pi*FishTank_radius**2*FishTank_height

#Displaying output
print("\n For a cylinder Tank shape:")

print("The volume of the fish tank in a cylinder shape is",(round(Volume,0)),
AmountWater_Hold = Volume/1000

print("The amount of water that the tank can hold is",(round(AmountWater_Hold
print("And one tiny fish needs 1.5l of water in order to survive in the tank")
  
```

Figure 10. Relying on the same video found on the Internet – Assignment 9 (2022)

In this example, the use of colour is illustrated as well, where sections of code are indicated in different colours – by Moss. It is worth noting that lines indicated in black are picked up so often by Moss, that it is not registered as similar.

- Cases piled up against some students who repeatedly were identified to be dishonest <DC_MULT>. It made it more difficult for a student to convince the lecturer of innocence on any one assignment problem. This occurred in 2021 and 2022.
- In a fair number of cases, the similarity percentage indication percentages are between 95% and 98%; overwhelming evidence of SCP <DC_C&P>.
- Whenever a candidate copied code with mistakes, the evidence is overwhelming <DC_ERR>. Three such examples are included here, namely:
 1. spelling mistakes (Figure 2),

<pre> if (25 < bmi < 30): print("Status: Overweight") if (18.5 < bmi < 25): print("Status: Healty") if (bmi < 18.5): print("Status: Underweight") print("Press enter to quit the program") #Inputs and choices if number 2 was picked elif (choice == '2'): ib = float(input("Enter your weight in pound: ")) inc = float(input("Enter your height in inches: ")) bml = float(round(ib/math.pow(inc, 2)*703, 1)) print(" ") print("BMI Report") print("Weight: ", ib,"ib") print("Height: ", inc,"in") print("BMI: ", bml,) if (bml >= 35): print("Status: Severely obese") </pre>	<pre> if (25 < bmi < 30): print("Status: Overweight") if (18.5 < bmi < 25): print("Status: Healty") if (bmi < 18.5): print("Status: Underweight") print("Press enter to quit the program") #code for weight in pounds and height in inches(choice2) elif (choice == '2'): weight = float(input("Enter your weight in pound: ")) height = float(input("Enter your height in inches: ")) bmi = float(round(weight/math.pow(Height, 2)*703, 1)) print(" ") print("BMI Report") print("Weight: ", weight,"ib") print("Height: ", height,"in") print("BMI: ", bml,) if (bml >= 35): print("Status: Severely obese") </pre>
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Figure 11. Proof of dishonesty by displaying the same spelling mistake – Assignment 7 (2022)

Note that the highlighting was done by the lecturer, when communicating with one of the students indicated in the similarity pair.

2. forgetting the peer's name and student number as comments (Figure 3), or

<pre> John Doe (12345678) import math num1 = int(input("Supply the first number: ")) num2 = int(input("Supply the second number: ")) sum = float(num1) + float(num2) print("The sum of the two numbers :", round(sum,1)) mul = float(num1) * float(num2) print("The multiplication of the two numbers :", round(mul,1)) min = float(num1) - float(num2) print("The second number subtracted from the first :", round(min,1)) div = float(num1) / float(num2) print("The two numbers divided is : ", round(div,1)) ave = sum / 2 print("The average of the two numbers :", round(ave,1)) rem = float(num2) % float(num1) print("The remainder of the divided numbers is : ", rem) power = math.pow(num1,num2) print("The second number to the power of the first is : ", round(power,1)) </pre>	<pre> John Doe (12345678). import math num1 = int(input("Supply the first number: ")) num2 = int(input("Supply the second number: ")) sum = float(num1) + float(num2) print("The sum of the two numbers :", round(sum,1)) mul = float(num1) * float(num2) print("The multiplication of the two numbers :", round(mul,1)) min = float(num1) - float(num2) print("The second number subtracted from the first :", round(min,1)) div = float(num1) / float(num2) print("The two numbers divided is : ", round(div,1)) ave = sum / 2 print("The average of the two numbers :", round(ave,1)) rem = float(num2) % float(num1) print("The remainder of the divided numbers is : ", rem) power = math.pow(num1,num2) print("The second number to the power of the first is : ", round(power,1)) </pre>
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Figure 12. Copy-and-paste, without changing the name of the original – Assignment 6 (2022)

3. using structures not yet covered in the syllabus (Figure 4).

```
#input from the user(name)
my_name=input("Please enter your name: ")
#input from the user(surname)
my_surname=input("Please enter your surname: ")
#input from the user with the number of columns(int)
mycol=int(input("Please enter the number of columns:"))
#print the name and the surname of the user
print(my_name ,my_surname)
#set a loop for the number of rows for your rectangle
#create another loop inside the first loop,
#to set command for number of columns
for i in range(5):
    for j in range(mycol):
        print("$",end="")
    print()

#get input1 from user eg name
myname = input("Enter your name: ")
#get input2 from user eg surname
myname2 = input("Enter your surname: ")
#get input from user on the number of columns,make sure its an integer
mycol= int(input("Please enter the number of columns: "))
#print the users name and surname
print(myname , myname2)
#initialize a for loop for the number of rows for your rectangle and,
#create another loop inside of the first loop,
#to initialize command for the number of columns.
for i in range(3):
    for j in range(mycol):
        print("*",end="")
    print()
```

Figure 13. Use of the selection structure, which was not yet covered in the syllabus – Assignment 5 (2022)

- In some cases, the Moss similarity indication in itself was enough evidence of dishonesty <DC_C&P> (Figure 5).

```
# program must calculate the two values and print the concatenated val
value1=str(input("Please enter value1: "))
value2=str(input("Please enter value2: "))
concatenated_values=value1 + value2
print(concatenated_values)
# calculate the sum of two values and print
number1=float(input("Please enter value1: "))
number2=float(input("Please enter value2: "))
sum=number1 + number2
print(sum)

# program must calculate the two values and print the concatenated val
value1=str(input("Please enter value1: "))
value2=str(input("Please enter value2: "))
concatenated_values=value1 + value2
print(concatenated_values)
# calculate the sum of two values and print
number1=float(input("Please enter value1: "))
number2=float(input("Please enter value2: "))
sum=number1 + number2
print(sum)
```

Figure 14. Classic copy-and-past– Assignment 5 (2022)

- Multiple cases of students started a conversation, but when confronted with the possibilities, did not reply. This phenomenon occurred in 2021 and 2022.

Discussion

In 2022 again, a large number of 134 individual students were caught in the act of being dishonest, with this figure is representing 62.0% of the final class enrolment of 216 students. It is a concern that the figure went up by more than 20% when compared to that of 2021, with 73 individual students identified as being dishonest among 179 students (40.8%). When comparing pass rates of candidates with dishonesty cases against them:

- Nineteen candidates (fifteen candidates in 2021) failed the module out of the potential 134 cases – 14.2% (73 cases in 2021 – 20.5%).
- Seventeen students (10 students in 2021) passed the module only after writing a second opportunity, at 12.7% (13.7% in 2021).

A percentage of 25.4%, just more than a quarter of the candidates (34.2% in 2021 – slightly more than one third), did not pass the module on the first attempt. Although the percentages seemingly improved from 2021 to 2022, the problem is a concern, and convinces the lecturer that students need to be aware of the existence of SCP and understand its impact on their learning and progress.

As was the case in 2021, when a dishonesty case was identified it is not always possible to distinguish between why a student is identified, since a student will not be able to copy code unless a peer supplies the code. Therefore, all categories are treated as dishonest. When analysing the candidates identified as being dishonest, who passed, they may be categorised as follows:

1. Some students could have been helpers <DC_HELP>, or
2. they did anticipate being caught in collaborating with a peer <DC_COLL>, but they thought that the lecturer would not use Moss to detect SCP, or
3. it may be possible that they did not anticipate that collaboration with a peer <DC_COLL> would be caught by Moss, or
4. it is possible that those who can code but did not have sufficient coding confidence during the semester, and therefore turned to SCP whenever they were unsure whether they would be able to solve a problem, without applying their minds to the problem at hand.

An attempt to make sense of the situation, and how these issues may be addressed in future, the situation is reflected upon below:

- It may be possible that the inexperience of students regarding the academic issues associated with plagiarism in general, and SCP specifically contribute to the SCP problem. Although students are theoretically made aware of the nature of plagiarism in the context of producing text, when it comes to programming, the principles differ slightly. Since code is similar to language, but much more structured, collaboration may easily result in pairs or groups of students identified as dishonest. A much more concerted effort should be made to help students to understand plagiarism in the context of source code. It is planned to put the support in place to be able to make students aware of each dishonesty case immediately after it occurs – from 2023 in some classes, and to enable this functionality across all introductory programming classes by incorporating a paid tool embedded in the official learning management system of the university. This way, a student will be able to track a potential dishonesty status themselves.
- It is true that although one party in a SCP relationship, as argued above, may be comfortable in compiling the solution to a problem, that same student is not comfortable enough to guide a peer into compiling an own solution. This may be the case with student assistants as well. A plan is in place to embark on a program to facilitate this situation by supplying students and students-as-assistance with guidance – from 2024.

Some initiatives which are not directly related to SCP, but may be of use in this context, include:

- It is anticipated that some underlying problems that are not directly related to the learning-to-code setting which students are typically facing, amplifies this problem. Some issues may be time-management, financial worries, a struggle to adjust in a new environment, and more. It is planned to interrogate these issues with the help of the 2023 intake of students.
- A paid tool should be investigated to guide students when they are doing non credit bearing coding exercises. The tool CodeGrade is on the budget for experimental use in 2024.
- CodeGrade will also be investigated as an assessment tool to speed up the assessment of multiple coding assignments completed by large groups of students.

Conclusion

The scope of this paper allowed the researcher to contemplate the initial two implementations of teaching Python, a subject module introduced in the curriculum as recently as 2018. Prior to the emergence of the Covid-19 pandemic, the detection of instances of code copying was not a primary concern, as face-to-face classes and

supervised sessions for significant tests and exams limited students' chances to plagiarise code. The onset of Covid-19 significantly disrupted the educational landscape, leading many students to explore novel methods for completing assessments, including copying code from peers during various instances of online and continuous assessment.

Although 2022 dishonesty case number were higher, but it seems to have a smaller impact on the pass rate of these students. It was the aim of the lecturer to make students aware of source code plagiarism – in 2021 and 2022, but the time and infrastructure constraints that led to using Moss only at the end of the semester, is not as effective compared to a situation which immediate feedback regarding grading and source code plagiarism is possible. Students only realise where they are at fault when they are made aware of the fact. Since students are driven by assessments, and therefore the marks they earn, they do sit up when they lose marks. This aspect was prioritised in 2023.

The 2022 offering was conducted in a similar way as 2021 due to the lingering effect of covid, but an important change in that it was not continuously assessed. Major assessments were done as sit-downs which were invigilated, also a breakthrough. It is anticipated that this research will be direct post-Covid implementations of the module.

Future research may focus on the aspects highlighted in the discussion – to ensure automation of various aspects of the subject module, which may afford more involvement of students to manage their own learning, and support lecturers to allow quicker feedback in terms of explanations, grading, and how to manage dishonesty.

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The impact of loadshedding on student academic performance: A data analytics approach

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Abstract

South Africa has a diversified population that reflects many cultures and religious traditions. A major problem known as Loadshedding affects a country that is rapidly progressing in terms of economic growth. Education is a key contributor to economic development, but Loadshedding is having an impact on the South African educational system. A thorough review of the literature revealed that there is insufficient research on this topic in South Africa to assess the effects of loadshedding on student academic performance. As a result, there is a need for more studies to gain a better understanding of the devastating effects of loadshedding on students. This study investigated the impact of loadshedding on the students' academic performance. To collect the necessary data, a survey was conducted using a questionnaire. Machine learning, a data analytics technique was applied to analyse the data to understand different variables, patterns, trends, and associations and allow us to make predictions about the impact of Loadshedding on the academic performance of students in South Africa. The findings indicate that Loadshedding has significant impact on the academic performance of higher education students. This research contributes to academic and society. Firstly, it helps to provide new insight to help expand knowledge on the effects of Loadshedding on academic performance in recent times. secondly, it will help educational institutions, stakeholders, parents, and students understand the effects of this crisis and take various measures to enable learning in a positive direction and continue with minimal learning disruption until the crisis is resolved.

Keywords: Loadshedding, Higher Education, Students, Academic Performance, South Africa.

Introduction

South Africa, with its diverse population encompassing various cultures and religious traditions, is facing a significant challenge known as Loadshedding—a recurring issue hindering the nation's steady economic development. Loadshedding refers to the deliberate reduction of electricity supply to balance the demand and available power. Its impact extends to every individual in South Africa, directly or indirectly. This problem first emerged in late 2007 and has since escalated, reaching a critical state in 2023 (Eskom, 2003-2012).

Electricity is an essential resource for the day-to-day functioning of the economy, powering machines and devices that drive various industries. The severity of Loadshedding is determined by the megawatts needed by Eskom, the national power

utility, to restore equilibrium to the electricity grid. Loadshedding stages range from 1 to 8, with higher stages indicating more severe power outages and longer durations (Loadshedding fact sheet, December 2019).

Notably, Loadshedding has had a significant adverse effect on South Africa's economic growth. A report by PricewaterhouseCoopers projects a decline in economic growth from an estimated 2% in the previous year to 1.7% in 2023, primarily attributed to ongoing blackouts caused by Loadshedding (PricewaterhouseCoopers, 2023). This situation poses a threat to various industries and hampers the ability of households to meet their daily requirements. Consequently, there is a pressing need for research on Loadshedding and its consequences.

The reliance on electricity for hardware, lighting, and educational resources makes Loadshedding a significant threat to the sustainability and quality of the curriculum and teaching across the country, from primary to tertiary institutions (Matsheta & Sefoka, 2023). An article published in 2023 examined a parliamentary question and answer session where the Department of Higher Education, Research, and Innovation revealed the substantial monthly expenses universities incur on fuel for generators to mitigate the impact of Loadshedding on classes and student learning (Businesstech, 2023).

Furthermore, statistics from the OECD's "Education at a Glance 2019" report indicate that only 7% of adults aged 25 to 34 in South Africa have completed university education (OECD, 2019). Looking ahead to 2020, this percentage is projected to be a mere 15% (OECD, 2022). Considering these figures, Loadshedding exacerbates the challenges faced by the educational system, potentially discouraging student enrolment and negatively impacting academic performance.

Despite the Loadshedding crisis persisting for over 15 years, South Africa has yet to find an effective solution, resulting in continued economic hardships. As a student, Loadshedding directly affects me and countless others in the education sector. Loadshedding not only directly affects education but also hinders economic progress in South Africa. To ensure uninterrupted learning and positive academic outcomes, it is imperative to conduct research on this topic and explore potential solutions. In this study, we aim to narrow our focus to the effects of Loadshedding on the educational system, employing data analytics to analyse its impact.

This study aims to contribute new knowledge to an existing problem, shedding light on the effects of Loadshedding on academic performance in recent times. The findings will benefit educational institutions, stakeholders, parents, and students, enabling a better understanding of the crisis's effects and facilitating the implementation of measures to ensure uninterrupted learning.

Background information

This section presents the theoretical information surrounding the impact of Loadshedding on student academic performance.

Theoretical overview of the study

Electric loadshedding

Loadshedding is the purposeful switching off energy supply to certain locations or users to manage a power shortfall in the overall electrical system (Kazmi et al., 2019).

According to Kucuk (2018), Loadshedding happens when the power supply is insufficient to fulfil the demands of the process loads. It is often performed as a last-option solution by the power supply company (Eskom in South Africa) to avert a total collapse of the energy grid. When the demand for power exceeds the available supply, Loadshedding occurs. This can occur for a variety of causes, including inadequate generating capacity, transmission limits, high consumer rate, or a combination of any two (Marzband et al., 2016). During peak demand periods, the power company may not have the capacity to meet the requirements of all customers, resulting in planned power outages.

Loadshedding as a threat to education

In South Africa, load shedding is a severe and persistent danger to education. Because of several issues, such as insufficient power generation capacity and infrastructural problems, the country has faced repeated electricity shortages and load shedding. A research study by Matsheta et al. (2023) addresses the critical issue of load-shedding in South Africa and its immediate impact on the right to education, specifically examining the "Section 29 Inquiry." The study highlights the severity of load-shedding as a significant threat to students' access to education in the country. The authors emphasize the importance of Section 29, which enshrines the right to education in South Africa's Constitution and investigate how frequent power outages disrupt educational activities and learning opportunities for students.

Loadshedding on academic performance of students

Electric Loadshedding significantly disrupts the lives of individuals, particularly in educational settings. Power cuts leave residences and institutions in darkness, while unplanned Loadshedding disrupts routines and contributes to poor academic performance. Power outages significantly impact students, especially during exam preparation (Jianjun et al., 2018). Prolonged power outages hinder learning processes that heavily rely on electricity, such as computer-based education and studying. Electric Loadshedding disrupts the flow of activities, resulting in the loss of unsaved work and negatively affecting students' health and education. It contributes to weakened eyesight among students and disturbs their daily routines, affecting national human capital Khan et al., (2022).

Coping strategies for electricity loadshedding

The study by Malik et al., (2022) explored the impacts of coping strategies used by university students during electricity Loadshedding in Pakistan. Using a quantitative approach, the research revealed that students employing initiative-taking coping mechanisms, such as using backup power sources and studying in alternative locations, experienced higher academic performance, and lower stress levels during power outages. In contrast, those relying on passive coping approaches faced more negative effects. Additionally, social support played a crucial role in mitigating the impact of Loadshedding, with students seeking help from peers, family, or university support services showing improved resilience and psychological well-being. The findings emphasize the significance of effective coping strategies and the need for support systems to assist students in managing power outages and related challenges.

Applications of data analytics in education

Data analytics has a significant impact on the education sector, offering valuable insights and improvements across various aspects of the learning process and educational management. Some key applications of data analytics in education include:

Learning Analytics: Learning analytics involves the analysis of student data to gain insights into their learning behaviours, performance, and engagement. It helps identify at-risk students, track progress, and personalize learning experiences based on individual needs (Tsai and Gasevic, 2017; Leitner et al., 2017).

Predictive Analytics for Student Success: Predictive analytics uses historical data and student performance patterns to predict the likelihood of academic success or failure. It allows educators to intervene early and provide additional support to struggling students (Cui et al., 2019).

Assessment and Evaluation: Data analytics helps in the analysis of assessment results to evaluate the effectiveness of instructional methods and identify areas for improvement in the curriculum (Pereira, et al., 2016; Secolsky and Denison, 2017).

Student Retention and Dropout Prevention: By analysing student data, institutions can identify factors that contribute to student attrition and implement strategies to improve student retention rates Ortiz-Lozano et al., (2018)

Learning Management System (LMS) Analytics: Data analytics can be used to analyse LMS data, providing insights into student engagement with online courses, content effectiveness, and overall course performance (Duin and Tham., 2020).

Early Intervention Programs: Data analytics allows educators to identify struggling students early on and implement targeted interventions to improve their academic performance (Alturki et al., 2021; Adnan et al., 2021).

By leveraging data analytics in education, educational institutions can improve student outcomes, enhance the learning experience, optimize resources, and make data-driven decisions to enhance overall educational effectiveness. However, it is essential to ensure data privacy and security while implementing data analytics solutions in educational settings.

The gap

This study aims to understand how Loadshedding affects students' academic performance. Previous research has suggested that Loadshedding can negatively influence assignment completion and studying (Malik et al., 2022). Students' academic success is a concern, especially with ongoing Loadshedding in South Africa, potentially hindering education access (Laguador & Dotong, 2020); Matsheta et al., 2023). However, there is a lack of research on Loadshedding's effects on academic performance between 2020 and 2023. Qakoshe (2022) highlights the potential long-term consequences for education due to the electricity crisis in South Africa. This study addresses this gap, aiming to provide insights into how Loadshedding impacts student learning and contributing to better educational outcomes.

Research method

This research aims to assess the impact of Loadshedding on student academic performance through the application of data analytics. Considering students' academic activities that involve the use of electricity, the following potential impacts of loadshedding were derived from previous studies conducted in different contexts (Anele et al., 2012a; Qakoshe et al., 2022; Malik et al., 2022; Bwalya et al., 2022) including.

Impact on assignment = 'ImpactAssignments'
Impact on attending lectures = 'ImpactLectures'
Impact on studying = 'ImpactStudying'
Impact on examination preparation = 'ImpactExamPrep'
Impact on access to alternate power = 'AlternatePower'

To achieve this goal, a cross-sectional survey was conducted using a questionnaire to collect the required quantitative data. The questionnaire comprises of three sections as described below.

Data collection instrument

The data collection instrument comprises a structured questionnaire divided into three sections, primarily consisting of closed-ended questions. These sections are outlined as follows:

1. *Demographic Information*: This section captures essential demographic details of the participants.
2. *Academic Information*: Participants are queried about their academic background and experiences.
3. *Loadshedding*: This segment delves into participants' experiences and perceptions related to Loadshedding.

A pilot test was carried to ensure the questionnaire covers the research aim and objectives. Feedback obtained during this phase was thoughtfully considered, resulting in necessary modifications. Our target sample population consisted of higher education students, drawn from Eduvos, a prominent higher education institution within South Africa. The participating students represent a subset of the broader student population in South Africa. This sample population was chosen because the study aims to reveal the impact of loadshedding on higher education students, thus, students' perceptions of the loading are required.

The population selection process employed non-probabilistic sampling techniques, specifically the convenience sampling method. This technique entails the selection of individuals who are easily accessible or readily available (Etikan et al., 2016; Okonkwo et al. 2022). Given the numerous higher educational institutions in South Africa, with their substantial student numbers, it is not possible to reach all the sample frame. Consequently, the convenience sampling approach was used. A total of 244 participants completed the online survey.

Ethical considerations

This study received authorization from the Institutional Ethics Committee (Permission No. FITREC230007). All participants were provided with comprehensive information about the study's purpose and procedures, ensuring complete transparency.

Data analysis

Several statistical analyses were conducted to ensure reliable and consistent results in line with the objectives of the study. Inferential statistics were employed to represent participant frequencies and response percentages (%) across all research variables. To ensure the credibility and reliability of the collected survey data, a reliability analysis was

performed with a minimum acceptable threshold of $\alpha = 0.60$. The average Cronbach's Alpha value of 0.75 was obtained with a confidence interval of 95%. This Cronbach's Alpha value signifies a favourable degree of coherence among the variables associated with academic performance and that the measuring items are suitable for the study.

Using a data analytics technique through Jupyter Notebook, a multi linear regression analysis was conducted to evaluate the relationship between the student experience with loadshedding (dependent variable) and potential impact of loadshedding on students (independent variables) including 'ImpactAssignments', 'ImpactLectures', 'ImpactStudying', 'ImpactExamPrep', AlternatePower. The chosen variables primarily centred on student academic performance and the effects of Loadshedding.

Survey results

A survey was conducted to obtain the participants views/understanding of the impact of Loadshedding on student academic performance. The results are as follows:

- 1) Participant's Profile:** This section covers the demographics of the sample population of students that participated in the survey.

Table 1: Participant's Profile

Gender		Sample of Participants	
Male 104 (44%)	Female 136 (56%)	244 Students (100%)	
Age Groups			
17 – 20 years (166)	21 – 23 years (57)	24 – 26 years (13)	26 + years (6)

- 2) Academic Information:** This section presents academic information about the sampled participants, focusing on their grade averages and their weekly study hours. Table 2 display the results.

Table 2: Academic Information of Participants

Weekly Study Hours					
1 – 10 hours 129 (53%)		10 – 20 hours 82 (34%)		20 – 30 hours 26 (11%)	
30+ hours 5 (2%)					
Grade Average Percentage					
Below 40% (5)	50-59% (32)	60-69% (88)	70-79% (88)	80-89% (25)	90-100% (4)

- 3) Loadshedding impact on students:** This section primarily examines how students are affected by Loadshedding during their different learning activities. It also investigates the difficulties caused by Loadshedding and explores the strategies students adopt to manage these challenges. Table 3 displays the obtained results.

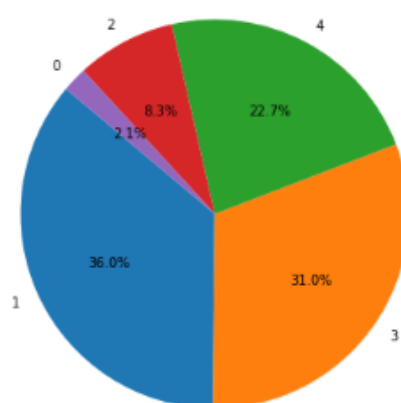
(Table 3 Participants were asked to respond with either Yes or No).

Table 3: Impact of Loadshedding

Construct	Agreed (Yes)	Disagreed (No)
Loadshedding Experience	221 (91%)	21 (9%)
Impact on Assignments	177 (73%)	65 (27%)
Impact on Viewing Lectures	179 (74%)	63 (26%)
Impact on Studying	162 (67%)	80 (33%)
Impact on Examination Preparation	154 (64%)	88 (36%)
Impact access to Alternate Power Sources	103(43%)	139 (57%)

How students manage their studying and task completion amidst Loadshedding conditions. The obtained results are displayed in Figure 1.

Distribution of alternate measures to take during Load Shedding



- 0 = Do not experience Loadshedding**
- 1 = Postpone studying until Loadshedding ends**
- 2 = Studying using natural light**
- 3 = Use alternative power sources**
- 4 = Use battery-powered devices**

Figure 1: Alternative measures to take during Loadshedding.

What challenges student encounter with Loadshedding. Figure 2 depicts the obtained results.

- Interruption of studying: Load... 147
- Limited access to electronic re... 150
- Disrupted online classes: Load ... 149
- Incomplete assignments or pr... 80
- Hindered exam preparation: L... 90
- Difficulty charging devices: Lo... 162
- Limited access to lighting: Loa... 121
- Increased stress and anxiety: L... 110
- Negative impact on schedulin... 115
- Limited access to internet con... 141
- Other 9

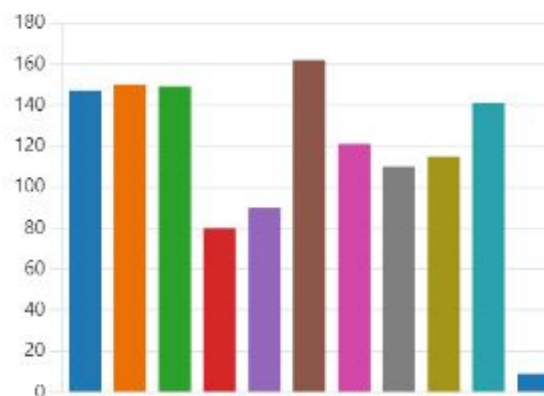


Figure 2: Challenges student encounter with Loadshedding

What strategies do students employ to cope with the challenges posed by Loadshedding? The obtained results are shown in Figure 3.

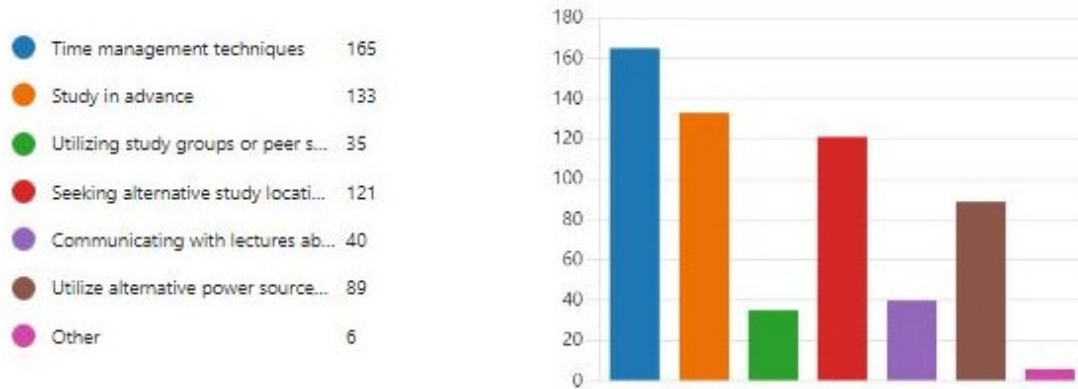


Figure 3: Students' coping strategies for Loadshedding challenges

(Note that figure 2 and 3 participants had the option to select multiple inputs)

Multi linear regression analysis

To comprehensively examine the correlation between Loadshedding and student academic performance, a multi linear regression analysis was undertaken. The dependent variable was determined as whether students experienced Loadshedding (LoadSheddingExp). Simultaneously, the independent variables were selected as ImpactAssignments, ImpactLectures, ImpactStudying, ImpactExamPrep, and AlternativePower. The initial four variables delve into the potential impact of Loadshedding on various aspects of students' daily routines, while the final variable (AlternativePower) explores whether students possess access to alternative power sources during Loadshedding occurrences. The ensuing results of this meticulous analysis are presented in the subsequent table.

Table 3: Results of Multi-Regression Analysis for Loadshedding and Student Academic Performance

Variable	Coefficient	Std Error	t-value	p-value
Constant	0.7013	0.048	14.582	0.000
ImpactAssignments	0.1056	0.049	2.134	0.034
ImpactLectures	0.1293	0.048	2.716	0.007
ImpactStudying	0.0722	0.043	1.679	0.094
ImpactExamPrep	0.0190	0.042	-0.454	0.650
AlternativePower	0.0065	0.037	0.176	0.860

Interpretations of the results

The research aims to explore how loadshedding affects students' academic performance in South Africa. In this empirical exploration, inspired by Khan et al. (2022), Four important variables were carefully identified and thoroughly analysed. To achieve this, quantitative data was collected from Eduvos a prominent higher education institution in South Africa. This data was carefully worked on and extracted, preparing it for a thorough statistical analysis to uncover important insights.

The research sample exhibited a balanced gender distribution, with 56% of participants identifying as females and 44% as males. This balanced participation highlights the

study's inclusiveness. The age range spanned from 17 to over 26 years, ensuring a diverse representation of students across various stages of education. This strategic inclusiveness is vital, as it permits a comprehensive understanding of how Loadshedding's impact transcends different age groups. Among the surveyed participants, A substantial number of participants were aged between 17 and 23 years.

In terms of study patterns, the data revealed that 53% of participants dedicate 1-10 hours to studying on a weekly basis, while 34% allocate 10-20 hours, 11% invest 20-30 hours, and a mere 2% engage in over 30 hours of weekly study. Moreover, the majority of participants exhibited average grades ranging between 60% and 79%, highlighting the representative nature of the survey population in terms of academic performance.

Load Shedding and Academics – The research examined how load shedding affects academics. The study explored various variables that assess how students manage their academic responsibilities, and the interpretations of these variables are provided below:

Load shedding experience – Among the surveyed participants, a notable finding emerged: 21 students (9%) reported that they are fortunate enough to be unaffected by load shedding. On the other hand, the majority, a substantial 221 students (91%), shared that they indeed experience the challenges of load shedding. This implies that a considerable proportion of students do not have adequate electricity supply for their studies. The finding agrees with Qakoshe et al., (2022) that students are impacted by load shedding,

Impact on assignments – It was found that 65 students, accounting for 27% of the respondents, indicated that load shedding does not affect their ability to complete assignments/projects. On the other hand, 177 students, making up 73% of the respondents, stated that load shedding does indeed have an impact on their ability to complete assignments/projects. This means that load shedding might have a substantial influence on students' assignments in a variety of ways, impacting their capacity to finish projects on time while maintaining quality. This finding aligns with Malik et al., (2022) noting that load shedding effects students' assignments.

Impact on viewing lectures – When the students were questioned about whether load shedding impacts their ability to participate in lectures, especially through online platforms, it was found that 63 students (26%) responded no, indicating that load shedding does not affect their ability to attend lectures. On the other hand, a significant majority of 179 students (74%) stated that load shedding does indeed affect their ability to attend lectures. This means that load shedding may lead students to skip classes, thus impacting their overall learning experience and academic advancement.

Impact on Studying – Concerning impact of load shedding on students' abilities to study, 80 students (33%) responded with "no." On the contrary, the majority of students, accounting for 162 students (67%), responded with "yes," indicating that load shedding indeed has an impact on their ability to study. This suggests that load shedding can have a major influence on students' personalised learning experiences, interfering with their capacity to participate in self-directed and individualised learning activities. This result supports the finding of Malik et al. (2022), who found that load shedding impacts student studies.

Impact on examination preparation – The impact of load shedding on the ability to prepare for examinations was assessed among 242 students. Of these, 88 students (36%) responded that load shedding does not affect their ability to prepare for examinations, while 154 students (64%) indicated that load shedding does indeed have an impact on their examination preparation. This means that load shedding might have a major influence on students' exam preparation, disrupting their capacity to study efficiently and appropriately prepare for exams. The findings agree with Malik et al., (2022).

Access to alternate power sources during load shedding - When queried about whether students have access to alternative power sources, 139 students (57%) responded "No," while 103 students (43%) answered "Yes," indicating that they do have alternative power sources available. While alternative energy sources can provide a temporary solution, there are still obstacles and factors to consider, such as cost, limited supply, dependability, environmental effects, and so on. This might have an influence on students' learning experiences. The finding supports the suggestion of (Anele et al., 2012b; Bwalya et al., 2022).

How students manage their studying and task completion amidst Loadshedding conditions – 36% of students choose to defer their studying until after Loadshedding, 31% proactively utilize alternative power sources, 22.7% rely on battery-powered devices which is a tip to beat Loadshedding, (UCT, 2023), 8.3% harness natural lighting for their studies, while a mere 2.1% are fortunate enough to be unaffected by Loadshedding. These findings illuminate the resourcefulness and adaptability of students in the face of such challenges.

Challenges student encounter with Loadshedding – Among the challenges encountered by students, the five most prominent hurdles emerged:

- a) Students grapple with difficulties in charging their devices.
- b) Students encounter limitations in accessing electronic tools and contents.
- c) Students face disruptions in online classes.
- d) Students experience interruptions in their study routines.
- e) Students contend with restricted access to internet connectivity.

Strategies students employ to cope with the challenges posed by Loadshedding – The predominant strategies adopted by students were:

- a) Application of effective time management techniques.
- b) Proactive studying.
- c) Exploration of alternative study venues.
- d) Utilization of alternative power sources.
- e) Proactive communication with their lecturers to address issues.
- f) Engagement in study groups and peer support.

A multi linear regression analysis was applied to explore the connection between Loadshedding and students' academic performance. The model fits well with $R^2 = 29.3\%$. Among these variables, a noteworthy subset, ImpactAssignments, ImpactLectures, demonstrated statistical significance with a p-value of less than 0.05 which indicates a practical significance (Ellis and Steyn 2003). The results explained that loadshedding has a practical impact on students by affecting their assignment activities and lecture periods. As students manage load shedding challenges in their daily routines and exam preparation, however, the strict deadlines for assignments and lecture schedules emerge

as critical factors that are directly affected by load shedding hours. Loadshedding's impact on these aspects, connected to academic success, directly affects student grades. This is possible because students' assignments come with defined instructions and due dates that they cannot change. Loadshedding can hinder or delay the completion of these assignments. On the other hand, lectures are fixed at a particular time, and if loadshedding occurs at that time, the affected students may not be able to join the lecture, especially in online classes.

Implication of the study

This study has theoretical and practical implications. In theory, the study also reveals a research gap in understanding Loadshedding's impact in South Africa, suggesting the importance of further investigation. This paves the way for more comprehensive research and informed interventions to address Loadshedding's challenges within the country. In practise, it emphasizes the need for educational institutions and policymakers to recognize the significant impact of Loadshedding on student academic performance. Variables like assignment completion and lecture engagement are notably affected, necessitating tailored strategies to counter these disruptions. Secondly, students can benefit from adaptive measures like effective time management and alternative study locations to mitigate Loadshedding's negative effects.

Conclusions, limitations, and future works

The study evaluates the impact of load shedding on student academic performance. A quantitative research approach was employed through a survey that included one higher educational institution within South Africa. Numerous factors were identified from previous related studies and investigated. Several statistical analyses were performed on the collected data to obtain the required results. The inferential statistics revealed that many the participants are affected by loadshedding especially on aspects of students' assignments, attending lectures, personalised learning, exam preparation, and use of alternative energy. Furthermore, a multi linear regression analysis confirmed that loadshedding has a practical significant effect of participants attending lectures and completing they assignments. The study offers additional insight into the effects of loadshedding on student academic performance in context of South Africa higher education.

Limitations and future works

The study's sample size may not fully represent the diversity of higher education institutions and student demographics in South Africa. A larger and more diverse sample could provide a more comprehensive understanding of the issue. Secondly, the study employs a cross-sectional design, capturing data at a single point in time. Longitudinal studies could provide insights into how Loadshedding's effects change over time and its impact on academic performance.

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Assessing the potential of chatbots as tutoring tools in engineering education: A South African case study

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Abstract

Artificial Intelligence (AI) has emerged as a transformative force in education, offering the potential to tailor learning experiences to individual students. Within Engineering Education, AI-powered Chatbots like ChatGPT have shown promise as virtual tutors, providing students with personalized support. Utilizing natural language processing and machine learning techniques, ChatGPT can understand and respond to student inquiries, enhancing the learning process. This study aimed to assess the effectiveness of ChatGPT as a tutoring tool at a University of Technology in South Africa. We applied the Plan, Do, Check, Act (PDCA) cycle, a Quality Management tool, to explore the potential of integrating chatbots as tutors. A survey involving 48 participants was conducted to collect feedback from students who have interacted with ChatGPT. Our findings indicate that ChatGPT is an effective tool for personalized tutoring. It demonstrates the ability to understand and respond to student inquiries accurately and efficiently, thereby enhancing the overall learning experience. However, it is essential to acknowledge the ethical and societal implications associated with the use of AI in education. In conclusion, while AI, exemplified by ChatGPT, holds tremendous promise, it is important to recognize that human tutors continue to play a valuable role in education. A harmonious integration of AI tutors and human educators can offer a more comprehensive and holistic learning experience. This study serves as a foundation for future exploration of AI's role in education and the continuous improvement of such technology-enhanced learning environments

Keywords: Artificial intelligence, Personalised learning, Engineering education, ChatGPT

Introduction

Artificial Intelligence (AI) promises to revolutionize education by facilitating the occurrence of personalized learning experiences for students (Chassignol et al 2020, Luan 2018). In the context of Engineering Education, one promising AI application is the use of Chatbots, such as ChatGPT, which can function as tutoring tools to support students. ChatGPT leverages natural language processing and machine learning techniques to comprehend and provide responses to student queries. Research by Hsu & Ching (2023) advanced several advantages of using ChatGPT from a student perspective, such as the chatbot can provide personalized learning support and assist with reading and writing comprehension. Essentially, performing as a teaching assistant, tutor or complementary

learning partner. Intelligent tutoring systems or personalized learning systems, According to Akgun and Greenhow (2022), are of the most popular and worthwhile uses of AI to support students and teachers.

Interestingly, Chan and Tsi (2023) found that while AI holds tremendous potential, human tutors still offer significant value, and a combination of both AI and human tutors may offer a more comprehensive learning experience. This study aims to investigate the effectiveness of ChatGPT as a tutoring tool for Advanced Diploma students in the Engineering Faculty of a University of Technology in South Africa.

Findings suggest that although some believe AI may eventually replace teachers, the majority of participants argue that human teachers possess unique qualities, such as critical thinking, creativity, and emotions, which make them irreplaceable. The study also emphasizes the importance of social-emotional competencies developed through human interactions, which AI technologies cannot currently replicate. The research proposes that teachers can effectively integrate AI to enhance teaching and learning without viewing it as a replacement.

Departmental context

This case study examines the perceptions of a specific cohort of part-time students in the Faculty of Engineering at a Higher Education Institution (HEI) in South Africa. Part-time students, who are often working individuals with families, face unique challenges as they strive to strike a balance between their studies, their personal lives and professional responsibilities. These challenges include limited time availability for their studies, variability in course load that can impact their performance, and the need for flexible options such as evening or weekend classes to accommodate their conflicting priorities. Financial burdens and a lack of time for extracurricular activities further contribute to their distinct circumstances. Notably, the university's tutor policy, which involves older students acting as tutors, does not align well with the time constraints experienced by our part-time students who mostly are already full-time employed. Consequently, tutors have not been appointed for this cohort since the inception of the qualification.

Moreover, the student numbers have doubled over the last two years, and where tutoring has not been identified as a need before, it is no longer the case. The growing student numbers have necessitated online teaching which impacts student engagement (or lack thereof) and could pose further challenges for student throughput. This according to Ellis (2019) could be ascribed to a number of reasons including student backgrounds, needs, expectations and behaviors to name a few. This particular qualification has gained popularity in that it can be of value in both manufacturing and service industries and could be the reason for the large enrolment numbers. Although the student numbers have increased the teaching staff numbers have remained the same and this is one of the key reasons for the decision to continue with online teaching.

Primary Research Question

The primary research question for this study is "*What is the potential of chatbots, specifically ChatGPT, as tutoring tools in the context of Engineering Education at a selected HEI in South Africa?*"

Investigative Research Questions

1. What role does ChatGPT play in supporting and enhancing the traditional classroom instruction for engineering students?
2. How effectively does ChatGPT respond to student inquiries, and to what extent does it contribute to their understanding of engineering concepts and theories?
3. What ethical considerations arise from the use of ChatGPT as a tutoring tool in South African Engineering Education?
4. What are the potential future applications of ChatGPT and similar AI technologies in the field of engineering education?

Conceptual framework

The PDCA cycle, widely recognized as a continuous improvement model and quality improvement framework, in various sectors including business, education, and healthcare, serves as a valuable tool for systematic problem-solving and quality management. Its acronym, PDCA, represents the key phases: 'Plan', 'Do', 'Check', and 'Act', embodying a systematic and iterative approach to continuous improvement. While the PDCA cycle is traditionally associated with Total Quality Management, this framework offers a valuable model guiding our research.

In the 'Plan' phase of the PDCA cycle, users identify a problem, establish specific goals, and devise strategies to attain them. We have done this in considering ChatGPT's role in education within the context of our study. Subsequently, the 'Do' phase involves executing the plan on a small scale to assess its effectiveness. During this phase, during the examination of our case study, we explore Chatbot Usage and Learning Impact, evaluating the specific effects of chatbot usage in our context. Moving into the 'Check' phase, the process involves assessing outcomes against established goals, scrutinizing data, and pinpointing disparities, and in our case, this included Ethical and Societal Implications. Finally, the 'Act' phase entails making necessary adjustments and improvements based on insights gained, thus initiating the cycle anew. This phase in our study expands its focus to Future Applications and Feedback.

While the framework was originally conceived for quality control purposes, the versatility of it extends beyond quality management applications. Researchers such as Pietrzak and Paliszkievicz (2015), Cowley and Domb (1997) and Maruta (2012) have employed the PDCA cycle in the examination of pedagogical strategies. Moreover, a distinctive aspect of the PDCA cycle, rendering it particularly suitable for research in the realm of learning, is its incorporation of both single and double loop learning - a concept originally proposed by Argyris and Schön (1978).

In the cycle, the single loop of learning involves incremental improvements to existing processes without questioning the underlying assumptions or goals. Essentially, it is making small adjustments to a plan to achieve better results. Double loop learning, on the other hand, involves questioning the fundamental assumptions and goals themselves. It goes beyond just adjusting the plan; it involves reevaluating whether the plan or strategy itself is effective and needs to be changed. Both incremental and fundamental changes in learning (Pietrzak and Paliszkievicz, 2015), are crucial for the sustainability of organizations that want to learn and adapt effectively. Organizations need to make small adjustments when needed, but also reevaluate and change their entire approach when necessary to improve learning and performance. In this way the PDCA cycle is flexible, accommodating both types of learning (single and double loop) and therefore is valuable

for researching and improving learning processes within organizations, such as in our case study, especially during strategic management efforts.

Literature review

The role of chatbots in education

Chatbots according to Kooli (2023) are automated colloquial instruments that use ordinary language processing learning algorithms to engage with users in a social way. There is no question that AI, and more specifically chatbots have developed into change agents in education, offering the potential to modify learning experiences for individual students. When engaging with students, chatbots could take on multiple functions such as teaching agents, peer agents, teachable agents, and motivational agents (Chhibber & Law, 2019; Baylor, 2011)

Research into the application of AI in the classroom according to Dilmurod & Fazliddin (2021) and Megahed, Abdel-Kader & Soliman (2022), can be traced back to almost 30 years ago. Adaptive learning technologies and AI could be perceived as key enhancements in educational technologies (Chatterjee & Bhattacharjee: 2020; Ouyang & Jiao, 2021), however the growth of AI in higher education calls for concerns including those of an ethical nature (Guan, Mou & Jiang: 2020; Alam: 2022).

According to Holmes & Porayska-Pomsta (2022) and Ye, Sun & Li (2021), intelligent virtual reality, intelligent aid for group learning, and intelligent personal tutors are the three types of AI software solutions employed in education. They further believe that Intelligent tutoring systems (ITS) could impersonate face-to face or personalized tutoring, and this could be achieved from observing learner models, algorithms, and neural networks. Intelligent virtual reality (VR) according to Bhimdiwala, Neri & Gomez (2022) and Nalbant (2021) is used to engage students in simulated and game-based learning environments. In settings like remote or online labs, virtual human take on the identity of a lecture, teacher or tutor.

According to Alam and Mohanty (2023), many research studies allude to the fact that education is best accomplished in a group setting and therefore further put forth that collaboration and discussion is crucial to the educational process. This notion is supported by Bii (2013) who argues that chatbots have the potential to encourage collaboration amongst students.

Usage of chatbots and its impact

According to Alam and Mohanty (2023) professionals predicted a 43% increase in the use of AI in education between 2018 and 2022. Research done by Okonkwo and Ade-Ibijola (2021) and Wollny, Schneider, Mitri, Weidlich, Rittberger, & Drachsler (2021) revealed that educational chatbots have the potential to support students' learning experience. Chatbots for example could encourage students, get them to participate, and present them with immediate assistance (Okonkwo and Ade-Ibijola: 2021). Wollny et al. (2021) is further of the view that educational chatbots make education more accessible and understandable. Benotti, Martnez, & Schapachnik, (2018), argue that aside from chatbots being cost effective their popularity is also due to their ability to provide a personalized learning experience to a student.

Winkler & Söllner (2018) reported that Chatbot adoption could be fundamental in online classes that include large student numbers where individual support from educators to students could become demanding. It is further possible for chatbots to provide an understanding of knowledge gained in the form of immediate elaboration of course content (Cunningham-Nelson et al., 2019),

Cordeur (2023) argues that AI/ChatGPT represents a crisis. A crisis can lead to a unique opportunity. It requires teachers/lecturers to be innovative in their thinking about classrooms. ChatGPT has shaken academics out of their academic nap. There is no longer a place for handing out notes which students must memorise. A paradigm shift is required similar to the mind shift made with the arrival of the internet. To keep up with the rapid development of AI and remain relevant, education is forced to adjust their approach to TLA. Furthermore Cordeur (2023) argues that ChatGPT is “*here to stay*”. He adds that although there are concerns, educational institutions have no choice but to prepare for the world of AI. It would not be wise to discourage students from making use of it. Students will use it, just like they use smartphones, calculators and Google. Rather we (as educators) must equip students with the skills to use ChatGPT critically and responsibly, in which case it can follow the same route as previous AI models. Finally he notes that while ChatGPT is here to stay, it will never replace humans. Just like other software, it facilitates calculations but still requires human intervention to find the right answers (Cordeur 2023).

Ethical and Societal implications

Nakhoda (2023) proposes AI is a vehicle to drive social justice, reduce inequality, and positively transform our society. He argues that AI literacy has become increasingly important, and it's essential to recognize that individuals proficient in AI will enjoy a distinct advantage over those lacking AI skills, often referred to as “AI-illiterate.” To address this, a comprehensive reform of our educational curricula becomes imperative. He asserts that HE institutions must integrate AI literacy and practical AI knowledge using AI teaching methods across all academic disciplines, embedding them into teaching and assessment approaches. This transformation signifies a substantial shift in higher education, while still upholding core principles like student support, individual values, attention to diverse needs, and the holistic well-being of both educators and learners.

Kong, Cheung, and Zhang (2021) share a similar view to Nakhoda (2023) stating AI is already present in some curricula but is often concentrated in specific, context-bound fields like applied sciences and engineering, while AI's relevance extends across societal contexts. Therefore, the goal is to make AI literacy pervasive throughout our curricula, spanning humanities, social sciences, law, philosophy, and all other disciplines. Constructive and meaningful university policies should guide this interdisciplinary endeavor. Nakhoda (2023) purports to achieve this transformation, it's crucial for all South African universities to collaborate on a curriculum revision project that spans every discipline. This effort aims not only to uphold the principle of leaving no student behind but also to ensure that no institution is left behind, reducing disparities among universities and fostering AI expertise through collaborative national think tanks.

Atlas (2023) warns against several limitations when using language models, including ChatGPT, in higher education. These include the absence of acknowledging human emotions, intentions and moral reasoning, the probability of using the tool to cause harm for example to highlight societal issues like discrimination together with the likelihood

of these AI language tools to propagate existing societal inequities. ChatGPT could also be manipulated in ways that aren't aligned with human values and beliefs and then finally the issue of guaranteeing the quality of the final product are perceived as the major challenges with ChatGPT and similar language tools.

Future applications

Our literature review now advances to potential future applications of chatbots in education and casts a spotlight on areas of improvement. It relates to the forward-looking aspect of technology-enhanced learning and continuous refinement based on user feedback. Koivisto (2023) is convinced that there is no doubt that there are a variety of advantages to assigning trained tutors as academic counsellors. Tutoring, as proven to be an exhaustive exercise, additionally the advice from the different tutors could be inconsistent and finally tutors can also only avail themselves for restricted amounts of hours.

Given the named limitations of human tutors, Hwanga and Chang (2021) and Song, Oh and Rice (2017) argue that chatbots positively impacted students' enthusiasm and attentiveness to their studies, while Kowalski, Hoffman, Jain and Mumtaz (2011) and Bii (2023) are of the view that chatbots encourages student engagement and (teamwork) collaboration. Neumann, Rauschenberger, and Schon (2023) contend that future users of AI tools like ChatGPT are poised to become more productive due to the technology's supportive nature. Disregarding the advantages of AI tools could be detrimental to students and hinder the growth of higher education institutions (HEIs). The authors further advocate for the integration of AI tools like ChatGPT into HEI courses. Significantly, research conducted by Cronje (2023) on the use of chatbots as peer coaches revealed that the quality of feedback provided by the chatbot is contingent on the quality of prompts, emphasizing the importance of students' ability to reflect. ChatGPT, like traditional computers, adheres to the 'garbage in, garbage out' principle, delivering feedback based on its programmed responses.

Zhang and Aslam (2021) predicted that the proliferation of AI technology will inevitably make an impression in education and its relevance will certainly increase, ensuring the possibility to offer tailor-made learning, provide arduous assessments, and to enable important relations in online, mobile or blended learning encounters. Srinivasan (2022), believes that the role of teachers is being reimagined by the influence of digital technologies and AI tools, from being the primary source of knowledge provision to take on more of an instructor and facilitator role in a class room setting.

Methodological approach

In this case study, we designed an intervention centered around ChatGPT for a group of 132 Advanced Diploma students. The aim was to support them in completing a semester project, which accounted for 15% of their final module grade. To introduce students to ChatGPT's capabilities, the subject lecturer provided guidance on its use. Subsequently, students received a project brief and were granted permission to use ChatGPT to produce a 15-minute instructional video on a statistical concept as a group assignment. After receiving feedback on their draft submission, they were required to submit the final project within two weeks.

Following the intervention, we administered an MS Forms online survey to all students who used the chatbot (n = 48). This survey comprised 25 Likert scale questions and five open-ended questions. One of open-ended questions aimed to assess personalization (related to the 'Do' phase), while the remaining four open-ended questions sought insights on Future Applications (connected to the 'Act' phase). Certain questions were reformulated and repeated in the data collection instrument using different phrasings to ensure reliability and validity of data. Prior to data collection, we obtained informed consent from the students. Ethical clearance to do this study was obtained on the 12th June 2023 ([2023FEBEFREC-ST-004](#)).

For data analysis, we conducted descriptive statistical analysis using the MS Excel spreadsheet generated from the MS Forms data collection tool. Additionally, qualitative data obtained from the five open-ended questions were thematically analysed to identify emerging and recurring themes aligned with the four phases outlined in the conceptual framework.

Findings

The findings of this study are presented in an order directed by the conceptual framework, the PDCA cycle and consistent with the sequence of the research questions presented above. Thus, the findings of this study are presented in four sections which are (1) Plan: The role of Chatbots in Education; (2) Do: Usage of Chatbots and its impact; (3) Ethics and Societal Implications and (4) Future Applications.

Plan: The role of Chatbots in Education

In the 'Plan' phase, which focused on the role of chatbots in Education, several questions shed light on students' perceptions. When participants were asked if they found the Chatbot to be a valuable supplement to classroom instruction, responses varied: 25% agreed "definitely", 23% said "most of the time", and 17% responded with "some of the time". However, 25% expressed uncertainty, while 5% stated "never".

Regarding the Chatbot's ability to maintain student motivation and engagement in the course, 23% participants responses were affirmative with "definitely, yes", 19% responded with "most of the time" and 25% acknowledged "some of the time". Conversely, 6% indicated "no" and 27% were uncertain. When queried about the Chatbot's adaptability to their learning style and preferences, 25% confirmed "definitely", 23% cited "most of the time", 19% recognized "some of the time", 8% asserted "never", and 25% were unsure.

In response to the question about whether the chatbot fosters meaningful discussion and collaboration among classmates, 31% agreed with "definitely", 21% with "most of the time", 15% with "some of the time", while 6% firmly responded with "no, definitely not", and 27% remained unsure. Lastly, in terms of the chatbot's role in supporting knowledge acquisition, only 10% reported "to a very high extent", 27% "to a great extent", 36% "to a moderate extent", 6% "to a small extent", and 19% believed it did not contribute to knowledge acquisition at all.

Do: Usage of Chatbots and its impact

When participants were asked about the frequency of using Chatbots as tutoring tools, the data showed that 6% of participants used them daily, 29% a few times a week, 21% once a week, 17% monthly, and 27% never. When assessing whether the chatbot provided

personalized support tailored to individual learning needs, 48% of participants answered in the affirmative, 25% were unsure, and 27% indicated it did not. Regarding the chatbot's understanding of questions and appropriate responses, 40% of participants felt the chatbot understood their queries and responded effectively, while 19% said “most of the time”, 13% said “only some of the time”, 6% reported never, and 23% were unsure.

In terms of accuracy and relevance of chatbot responses, 31% indicated “yes, always”, 23% “most of the time”, 21% “some of the time”, 4% “never”, and 21% were unsure. Regarding the importance of immediacy in receiving responses from the chatbot tutor, 56% considered it extremely important, 19% “somewhat important”, 19% “neutral”, 4% “somewhat not important”, and 2% “extremely not important”. For the question concerning the chatbot's assistance in understanding concepts and theories related to studies, 35% felt it helped always, 21% “most of the time”, 17% only “some of the time”, 8% “never”, and 19% were unsure.

When asked if the chatbot provided sufficient explanations, 33% said “yes”, 19% “most of the time”, 21% “some of the time”, 4% “never”, and 23% were unsure. This was one of the questions that was asked in slightly different ways to enhance result reliability. Regarding confidence improvement in learning abilities, 27% felt more confident, 27% “most of the time”, 17% only “some of the time”, 8% “never”, and 21% were unsure. For the impact on grades, 17% said “yes” 25% said “most of the time”, 15% “some of the time”, 15% “no”, and 29% were unsure.

In terms of identifying weaknesses in knowledge or skill, 25% responded “yes”, 21% “most of the time”, 17% “some of the time”, 8% “no”, and 29% were unsure. For developing better study habits or improving time management skills, 27% answered “yes”, 17% “most of the time”, 23% “only some of the time”, 8% “no”, and 25% were unsure. Finally, when asked if additional human tutor or instructor support was needed while using ChatGPT, 29% said “definitely”, 33% “only some of the time”, 6% “most of the time”, 10% “no human tutor support needed”, and 21% were unsure.

Check: Ethics and Societal Implications

In the ‘Check’ phase, where we explored Ethics and Societal implications of ChatGPT, we inquired about participants’ stance on the ethicality of employing AI for supporting learning. Thirty-eight (38) % felt it was ethical, while 21% responded with 'most of the time.' Another 21% acknowledged 'some of the time,' while only 6% expressed a resolute 'no, never,' and 15% remained uncertain.

In response to our query about their comfort levels when utilizing Chatbots as tutors, only 10% expressed a firm “yes, definitely”, they feel uncomfortable when using ChatGPT. Examples of reasons provided by participant as to why they felt uncomfortable were “*Does not giving sources of info*” and “*System does not give backgrounds maybe that's why i have doubts sometimes about an information provided to me. Maybe I need to educate myself more or use it frequently.*” From the latter, we glean that the novelty of the technology may be the reason for the discomfort. Notably, only 6% report preferring traditional tutoring methods. Two (2) % leaned toward “most of the time”.

A significant 17% admitted feeling uncomfortable “only some of the time”, but the majority, comprising 48%, confidently declared they don't feel uncomfortable, and 23% remained uncertain. Subsequently, when assessing the extent to which the Chatbot

contributed to the production of high-quality course outputs, a noteworthy 19% firmly asserted “yes, definitely”, while an equal 19% predominantly stating “most of the time” Substantially, 29% indicated “only some of the time”, and a modest 8% unequivocally stated “no, never” Twenty-five (25%) were uncertain about the extent of its contribution to high-quality academic output.

Act: Future Applications

Perspectives shared by the research participants also provided valuable insights into the potential future applications of ChatGPT. Positive perspectives, such as “*ChatGPT is a tutor that can be accessible from home, bus, school, work*” and “*I imagine it as an around-the-clock tutor who can undoubtedly assist us with the world of work*”, highlight the enthusiasm for ChatGPT as a versatile and accessible learning tool that can support users in various settings.

However, it's equally important our participants highlighted challenges such as “The chatbot is not always giving you the correct answers” and “It can simplify and make one understand, but sometimes it just gives answers that don't make sense or are different from what you've asked” which underscores the need for ongoing improvements in accuracy and responsiveness of the technology.

Furthermore, the suggestion that “*...new information must be added, like regulatory requirements*” emphasizes the importance of continually updating and expanding the knowledge base of ChatGPT to ensure its relevance and effectiveness in addressing a wide range of user queries and learning needs. These insights collectively contribute to a more comprehensive understanding of ChatGPT's potential in future applications while highlighting areas for refinement and enhancement.

Participant responses also underscore the importance of two key aspects: awareness-building and user training. Their responses shed light on the need to enhance awareness and educate individuals on how to effectively utilize chatbots. Examples of participant responses regarding their workplace experiences and the skills gained through Chatbot interactions further emphasize these points. Comments such as “*The tool opened my eyes and had to ask my colleagues about it. Some were unaware had to educate myself and make others also aware of the tool*” along with “*So far the peers were unaware about the tool and some had to navigate to actually have an understanding what it does*” and “*To my surprise, some colleagues at work had not known about this excellent technology, which was definitely an advantage for me*” collectively highlight the need for proactive initiatives to promote awareness and provide training for chatbot utilization in both workplace and educational settings.

Discussion

Discussion on the role of Chatbots in Education

Consistent with the views of Holmes and Porayska-Pomsta (2022) and Ye, Sun and Li (2021), our study deduced that chatbots are a useful, supportive and flexible teaching tool. Most of our research participants (73%) found chatbots, ChatGPT specifically, to be a valuable supplement to classroom instruction, and only 5% stated that they did not believe it supplemented classroom instruction at all. We noted that participants were more divided on the ChatGPT's ability to maintain their motivation and engagement. They also had mixed opinions on the chatbot's ability to adapt to their learning style and preferences. Our respondents believe the chatbot fosters meaningful discussion and

collaboration among classmates, however the chatbot's role in supporting knowledge acquisition was moderate, as 36% reported "to a moderate extent," while only 10% reported "to a very high extent". We attribute this finding to the nature of our study, where students were tasked with creating a video based on concepts already covered in class. Consequently, the chatbots use was primarily knowledge consolidation, akin to the role of a tutor.

Discussion on Usage and Impact

Grounded in the forgoing discussion, we noted that only 10% of our research participants felt they did not need additional human tutor support when using the chatbot, and 68% indicated they prefer human tutor support in addition to ChatGPT. Significantly however, only 12,5% of the participants articulated that they were sceptical or fearful of AI tutors replacing human tutors. An inference made from this is that our research participants believe there should be a balance of human tutors and chatbots (AI tutors) support, with the immediacy of responses being cited as the top advantage (56%) of using chatbot tutors.

Reflecting on the overall impact of chatbots as tutors, this study concludes that the chatbot's ability to facilitate tailored learning experiences is a significant advantage as nearly half (48%) of participants highlighted this as a reason for using it as a tutor. A significant portion (40%) felt the chatbot understood their queries and responded effectively. The accuracy and relevance of chatbot responses were however a point of contention, with only 31% indicating that responses were consistently accurate and the remaining 69% held varying degrees of neutrality or opposing views on its accuracy and relevance (19% most of the time and 13% only some of the time). Despite this, 54% of the participants reported using the chatbot boosted their confidence and therefore, we deduce that in general the chatbot has more of a positive impact on learning and teaching. Aligned with the views of Cordeur (2023) and Nakhooda (2023), our study demonstrates that AI chatbots, such as ChapGPT, have established themselves in HE. The unfolding consequences of this are irreversible, akin to Pandora's box having been unsealed. These findings imply that, as HE educators, we must embrace innovative approaches when thinking about AI and how to integrate it into pedagogy. ChatGPT has shaken us out of an academic nap. Our findings remind us that HEI campuses have transcended their role as mere repositories for the dissemination of memorization-based study materials. Similar to the pivot that occurred with the arrival of the internet, a paradigm shift is once again required. To keep up with the rapid development of AI and remain relevant, the role of educators must be adjusted to make room for AI tutors.

Discussion on Ethics and Societal Implications

Significantly, most of our research participants did not feel it is unethical to use ChatGPT for their learning, and a similar majority did not experience discomfort when using this technology. Thus, our analysis of the findings of the check phase leads us to conclude that the primary reason for some students feeling uneasy may be the novelty of this new technology and the ambiguity surrounding its usage, particularly the absence of clear guidelines.

Furthermore, it's worth noting that most students expressed confidence in ChatGPT's ability to produce high-quality academic work. In line with Nakhooda's (2023) perspective, we assert that the increasing prevalence of AI, in particular ChatGPT presents a truly distinctive opportunity for universities to comprehensively rethink their

strategies and roles in our rapidly evolving world. As stewards of the knowledge economy, our institutions are compelled to take the lead in this transformation, actively shaping its course through introspection and meaningful actions. We believe this presents our best opportunity for fostering innovation and advancing social justice.

Discussion on Future Applications

Drawing on the findings of the 'Act' phase of this study, it appears that the advent of ChatGPT introduced a novel and valuable resource to the participants' workplace environments. A common theme emerges where many of their colleagues or peers were initially unaware of the Chatbot's existence or capabilities. This lack of awareness prompted the participants to take on the role of educators, sharing their knowledge and insights about the Chatbot with others in their workplace.

Furthermore, there is a consistent recognition among the participants that their familiarity with and utilization of the Chatbot provided them with a distinct advantage in their professional responsibilities. It empowered them to complete tasks more efficiently, such as writing Standard Operating Procedures (SOPs), and contributed to their overall competence in the workplace. Overall, the trend reflects the dual impact of the Chatbot: its introduction as a valuable tool that enhances individual productivity and its subsequent dissemination as users share their newfound knowledge with colleagues, thereby expanding its presence and utility in the workplace.

Recommendations for future research, theory and practice

Reflecting on the findings of this case study, we recommend future research on Chatbots in education should explore their adaptability to diverse learning styles and preferences, moving beyond knowledge consolidation. Moreover, at present there is a dearth in knowledge on the impact of Chatbots on motivation and engagement in classroom settings. Supporting other researchers (Cordeur, 2023; Nakhoda, 202; Holmes and Porayska-Pomsta, 2022 and Ye, Sun and Li 2021), it is evident that further research is needed on the integration of Chatbots into classroom instruction, as this is crucial for gaining a comprehensive understanding of their educational value.

We also believe understanding the ideal balance between human and AI tutor support, along with factors affecting the accuracy of Chatbot responses, requires further exploration. In terms of ethics and societal implications, future research should focus on developing clear guidelines to alleviate discomfort and ethical concerns among students. Additionally, examining the broader societal ramifications of AI integration in learning and their effects on educational policies is another recommendation of this study.

Finally, in terms of future applications of Chatbots, understanding the long-term impact of Chatbot integration in workplaces and assessing changes in productivity and efficiency is also a recommendation of this study. Future research exploring the knowledge and skills most effectively enhanced through Chatbot interactions in professional contexts would provide practical insights for future implementation.

Limitations for the study

We acknowledge that our case study has some inherent limitations. First, the rapid evolution of technology, particularly in the field of AI, poses a challenge. Despite our data collection efforts in July 2023, the landscape may have evolved since then,

potentially rendering our findings outdated to some extent. We acknowledge that if the survey were to be administered to students at a later date, the results might differ.

Second, our study focused on a single cohort within a specific department. As a result, the generalizability of our findings to broader educational contexts may be limited. While our research provides valuable insights within the scope of our study, caution should be exercised when applying these findings to different academic settings or student populations.

Conclusion

In a world marked by rapid technological advancements, the emergence of Chatbots such as ChatGPT, mirrors previous transformative shifts in HE, such as the internet's arrival. This has raised concerns regarding the potential overreliance on AI technologies like ChatGPT, with apprehensions about the displacement of human educators and the possible stifling of critical thinking skills.

Nonetheless, our study underscores the pressing need for a paradigm shift in educational strategies, incorporating chatbots in pedagogical approaches to remain pertinent and to harness the full potential of AI in education. As the custodians of the knowledge economy, educators and institutions must assume leadership roles in driving this transformation, actively guiding its trajectory through introspection and meaningful actions. This transition period we find ourselves in presents an unparalleled opportunity for fostering innovation and advancing social justice, and ultimately propelling the field of education into an era where human and AI collaboratively facilitate learning and knowledge dissemination.

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