digiTAL 2021

Conference Proceedings

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Editorial

This conference proceedings of the second digiTAL conference, themed “THE JOURNEY BEYOND”, showcases research and practices which have come around based on need, the COVID pandemic, and the need to ensure education progresses in adverse challenges.

This second conference was held on 2nd and 3rd December 2021 once again in a completely digital environment due the effects of the disruptive era of COVID-19. A total of 68 papers submissions were accepted from South Africa, Zimbabwe, Ghana, Mauritius, Italy, Australia, Oman, Kenya, India and Zambia. The outcome of this overwhelming response has been two publications, a book of abstracts with 40 abstracts and a conference proceeding with 20 fully double blinded refereed papers. The papers covered many areas including COVID-19 in higher education, pedagogical practices in online and distance education, curriculum design, student engagement in the digital environment, digital environment in the secondary school’s quality assurance in an online environment and subject specific digital teaching and learning research.

This 2nd edition of digiTAL2021 showcases the richness of research that takes place internationally within the walls of the ivory towers of the higher education sector.

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, Australia, Amity Institute of Higher Education, Mauritius, and e-Merge Africa, South Africa.

Professor Sid Nair (Victorian Institute of Technology, Australia)
Dr. Upasana Singh (University of KwaZulu-Natal, South Africa)
digiTAL 2021 Co-Chairs

Preface

Necessity is the mother of invention, and Prof Yunus, Nobel Prize Winner, often adds, “and science-fiction is the father”.

COVID-19 has brought us on the brink of a breakdown in various spheres of the previous “normal” society. Yet, life had to go on, and this brought humanity to look into new ways, adapt existing or overlooked means, to continue routine “normal” activities.

Yet, COVID-19 allowed the world the luxury of a paradigm shift. Suddenly, video call and online meeting applications and platforms became the essential commodity when they were for years taken as an unwanted solution that prevented physical, social interaction and mobility of people. Internet became the only way to be connected to the outside world and the main channel for many activities, like shopping, socializing and education.

An old Science-Fiction movie talked of space as “the final frontier”, and the digiTAL 2021 conference theme, “The Journey Beyond”, is a fitting phrase that brings me back to the words of Prof Yunus. In its traditional form, education was so deeply rooted in the face-to-face mode that the pandemic has indeed brought unprecedented chaos. Academia, in collaboration with industry, is a powerful and resourceful duo. We are delighted by the number of solutions that cropped up to improve and maintain education services. Thus, we saw novel ways to conduct exams, we saw regulatory bodies finally accepting online assessment, the use of virtual reality and specialized apps for practical sessions. We have come a long way since December 2019, yet, there is much more in the journey ahead. Education is also about quality, relevance and currency. How can digital education activities be quality assured? How can a lecturer ensure the students are receptive to the online teaching? So many questions require further discussions before we reach some degree of agreement.

This conference comes at a very opportune time. We look forward to excellent contributions, insightful ideas and novel ways of improving the education sector.

I wish all of you a happy Conference.

Prof Kiran Bhujun
Director and Vice-Chancellor
AMITY (Mauritius) - digiTAL 2021’s conference associate

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DHET Conference Compliance Letter
(for SA Authors)

To whom it may concern,

The digiTAL 2021 conference was hosted virtually due the COVID-19 pandemic, from Durban South Africa, in association with Victorian Institute of Technology, Australia; Amity Institute of Higher Education, Mauritius; and e-Merge Africa, South Africa, from the 2nd to 3rd of December 2021.

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 978-0-620-91827-5 (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.5) and/or organising committee (see Pg.6), 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: 20th December 2021

The Impact of COVID-19 on Students Completing a Blockchain Course

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Abstract
The growing popularity and use of Blockchain technologies by crypto-currencies, such as Bitcoin, has forced education institutions to introduce new Blockchain courses. The Blockchain courses consist of theoretical and practical components. The practical components require students to work with new technologies, such as programming in Solidity on the Ethereum Blockchain platform. The COVID-19 pandemic is an international concern, which has affected students and academics. Education institutions have had to switch to digital ways to present course material. Students had to use different technologies to complete their studies, adjust to working from home and cope with various pandemic challenges. Programming oriented courses require students to complete practical assignments and students rely on academic support during these sessions. The purpose of this study was to compare the offering of an Honours Blockchain course before and during the COVID-19 pandemic. Students on the Blockchain course complete course evaluations annually. The results were thematically analysed and indicated that the students during 2020 had to face additional challenges, such as working from home with limited assistance when completing practicals. They had to solve Blockchain coding related problems by using programming forums and Internet programming sites, YouTube videos and Blockchain related blogs. Thus the 2020 students had a more 'real-world' programming experience, problem-solving on their own, without the face-to-face assistance from experienced instructors during practical sessions to assist with coding problems.
Keywords: *Blockchain course, COVID-19 impact, Course evaluation.*

1. Introduction
Online education has become a part of the academic teaching milieu, due to the worldwide COVID-19 pandemic. The COVID-19 pandemic has changed teaching and learning in higher education specifically. Overnight, universities around the world have had to migrate from face-to-face engagements to online learning. The standard teaching approach has changed drastically and online education has become popular through platforms, such as MOOC, Cousera, edX and Code.org , including universities, such as Harvard, MIT and Stanford (Settle, Vihavainen & Miller, 2014). Online sites that promote the teaching of computer programming, particularly to school children, such as Code.org, Codecademy and Khan Academy have gained popularity. Teaching online changes, the mechanism of learning and has caused some difficulty for academics (Saminathan & Hemalatha, 2021). Remote learning has brought about challenges for both academics and students that they have not experienced before. The constraints created by the COVID-19 pandemic have created the need for innovative methods of presenting courses and study material. The lockdown procedures, initiated to slow down the spread of the COVID-19 virus, have forced people into isolation. The adaptation to social isolation disrupts a person's normal way of life (Smith & Barret, 2020). The COVID-19 pandemic has disrupted the lives of students in different ways, depending not only on their level and course of study, but also on the point they have reached in their programmes and ultimately opportunities to enter the labour market (Daniel, 2020). The combination of isolation and disrupted lives has resulted in levels of stress, which require people to cope.

Stress in education is a given and in 2020, stress has increased due to the COVID-19 pandemic. Many students confined at home due to COVID-19 may feel stressed and anxious (Di Pietro et al., 2020). Stress and coping are widely researched fields in the field of psychology, but have received increased attention in higher education (Sprang & Silman, 2013). Stress is defined as a particular relationship between the person and the environment, appraised by the person, as taxing or exceeding his or her

resources and endangering his or her well-being. Students who are isolated during pandemics are likely to suffer from acute stress disorder and adjustment disorder (Sprang & Silman, 2013). Although the adoption of distance learning is key to ensuring the continuity of education during the closure of learning institutions, it is assumed that students will experience a learning loss during the lockdown (Di Pietro et al., 2020). This loss will translate into a reduction of available human capital in the future. The lack of student interaction influences achievement through peer effects and the acquisition of social skills (Di Pietro et al., 2020). Online teaching and learning imply a certain pedagogical content knowledge (PCK) related to designing and organising for better learning experiences and learning environments, using digital technologies (Rapanta et al., 2020). The lack of PCK or pedagogical preparedness for online teaching has been one of the significant challenges for academic staff.

The switch to online has offered an opportunity for asynchronous learning. Asynchronous learning is defined as 'not keeping time together'. Students have the ability to access information, demonstrate what they have learnt and communicate with fellow students and lecturers in their own time, allowing for flexibility (Daniel, 2020). The design of an online course requires a student centered approach, with the lecturer facilitating the student's competence development. It allows for self-paced learning and reflection (Rapanta et al., 2020). In this learner centered approach, students can pace themselves and develop their own learning schedules. The demonstration of mastering the course content is comprised of a portfolio of evidence (Trach, 2018). Courses on computer programming are included in the curricula of almost all tertiary institutions. Computer programming is considered difficult and abstract, with complex concepts and structures (Alammary, 2019). Students are taught about data types, variable declaration, operators and expressions, encapsulation, abstraction, inheritance and polymorphism, arrays and strings, pointers, user-defined data types, functions and recursion and file handling, amongst other programming concepts.

Visual programming and game-based learning can enhance computational thinking and problem-solving skills when students learn to program (Chakraverty & Chakraborty, 2021). Computer programming courses are generally presented by Higher Education Institutions (HEIs) face-to-face and online. The practical component of computer programming generally caters for instructors, using different techniques, for teaching these courses in a computer lab environment (Chakraverty & Chakraborty, 2021). Students are provided with instructors and assistants, who are usually senior students, to assist those completing practical assignments. Blockchain was initially associated with Bitcoin, however its application has grown far beyond cryptocurrencies due to the introduction of smart contracts. Smart contracts are self-enforcing pieces of software, which reside and run over a hosting Blockchain. The growth in the popularity of Blockchain, specifically industry related applications, has necessitated education institutions to introduce Blockchain courses. Blockchain courses require students to use new technologies, programming environments and introduce many new concepts.

The aim of this study was to determine and compare the experiences of Honours students at the Nelson Mandela University (NMU), Department of Computing Sciences who completed the Honours Blockchain course before the COVID-19 pandemic and those students who completed the course during the lockdown period. The transition to online and students working remotely during the lockdown period, were investigated. The research question addressed in the paper is how did the COVID-19 pandemic affect the Honours Blockchain students differently compared to students who completed the course pre-COVID-19. The layout of the paper is as follows. In Section 2, the research problem and research questions being investigated are introduced. Section 3 provides a literature review, which focuses on adoption decision theory. The results are discussed in Section 4 and the paper is concluded in Section 5, where limitations and future research are also presented.

2. Research Problem and Research Design

Teaching students to write computer programmes is a difficult task and has been researched for decades (Alammary, 2019; Settle et al., 2014). New teaching and learning techniques and tools are used by instructors to improve students' learning experiences. Developing countries have experienced inequalities, additional challenges and benefits due to sudden transformation to the online pedagogy (Oyedotum, 2020). Teaching programming on-site or face-to-face have resulted in the development of practices and guidelines, supported by educational theory and empirical research findings (Settle et al., 2014). In contrast, limited educational practices have been developed for the teaching of programming. Research that compares on-site teaching of programming courses with on-line teaching have only recently been researched (Alammary, 2019).

The research problem addressed in this study was that the impact of the COVID-19 pandemic has on students completing an Honours Blockchain course has not been determined. Students are annually required to complete a course and teaching evaluation. The qualitative course evaluations completed by students pre-COVID-19 and during the Covid-19 pandemic were thematically analysed and compared. The research philosophy used in this study was interpretivism, the guiding paradigm and approach was qualitative, inductive and exploratory. Interpretivism helps with the interpretation of how people participate in social and cultural life (Saunders, Lewis & Thornhill, 2019). This study was one of many investigations on the impact of COVID-19 at Higher Education Institutions (Cullen et al., 2020).

The statements and questions listed below, form part of the annual course and teaching evaluations students are required to complete per course. The anonymous responses were thematically analysed to determine how the students were coping and their opinions about the Honours Blockchain course:

- Please list or describe excellent aspects of the lecturers' teaching.
- Please list or describe aspects of each lecturers' teaching that needs attention.
- Please list or describe excellent aspects of the course.
- Please list or describe aspects of the course that needs attention.
- Please make general comments about this course/module.
- How could the practical component be improved?
- What are your views of the practical component of the course?

In order to analyse the qualitative responses received, thematic analysis is conducted (University of Auckland, 2020). Extracting trends from text responses is normally achieved by grouping comments containing the same keywords together as themes. The qualitative data were thematically analysed using AtlasTi. The presentation of the thematically analysed results, generally includes key findings under each main theme, using appropriate verbatim quotes to illustrate the findings, using different graphical diagramming techniques and graphs. The graphical diagramming techniques include the Atlas.Ti network graphs (Figure 1) and word clouds (Figure 2).

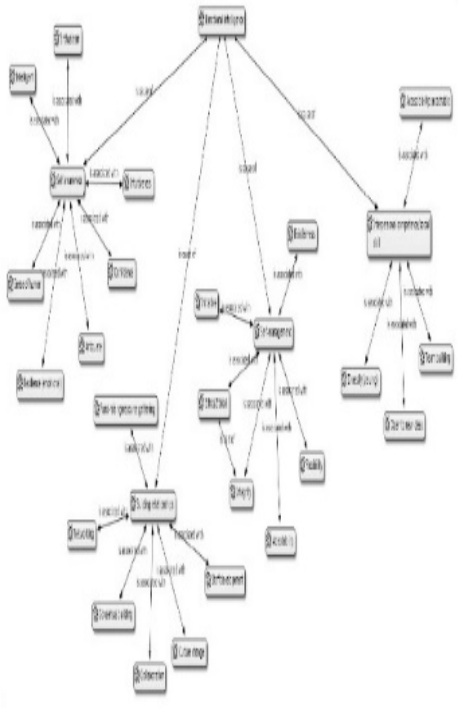

Figure 1: AtlasTi network diagram

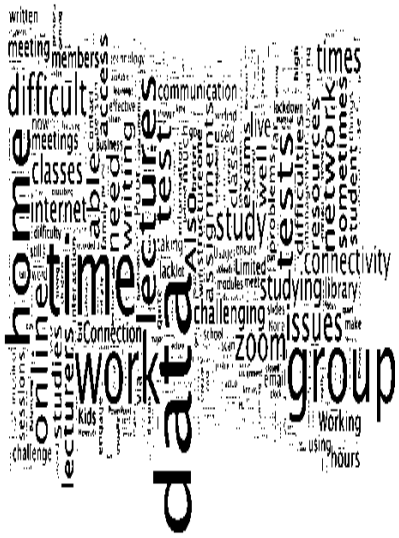

Figure 2: Word cloud

The study was qualitative and open-ended questions were included in the questionnaire, which was distributed to the participants online, using the survey tool, Questionpro. The results were analysed using both thematic analysis and content analysis. The responses were initially analysed using the software package, AtlasTi and the results were visually presented using Theme Frequency and Association Diagrams (TFAD). TFAD shows the identified themes, the number of respondents who mentioned the theme and the associated themes. The association highlights the fact that respondents mentioned more than one theme in their responses.

3. Literature Review

3.1 Theoretical Framework

The global COVID-19 pandemic has forced teachers and lecturers globally to develop new strategies for knowledge sharing (Sheng-Bo Huang, Jeng & Lai, 2021). Understanding educational theories and learning theories increases the knowledge of how educators teach and how students assimilate the knowledge presented (Wittmann-Price, & Price, 2018). Learning Theories describe how students absorb, process and retain knowledge during the learning process (Shaaban, 2021). A number of learning theories can be included in a theoretical framework. The How People Learn (HPL) model describes four areas that instruction should include, namely:

- *Student centered* driven by the knowledge, skills, attitudes and needs of the student;
- *Knowledge centered* focused on helping students develop a deep understanding of the content and processes of the discipline;
- *Assessment centered* keyed to both formative and summative evaluation with frequent and informative feedback and revision; and
- *Community centered* based in a community of learners within the learning situation and connected to the community at large.

The principles of good practice (Shaaban, 2021) encourage amongst others:

- Contact between students and course presenters;
- Feedback;
- Active learning techniques; and
- Respect for diverse talents and ways of learning.

The COVID-19 pandemic has also affected the learning styles of students (Shaaban, 2021). Specifically, the verbal, physical and social learning styles have been affected by online learning.

3.2 COVID-19 Impacts on Students

The COVID-19 pandemic has affected students, academics and other stakeholders at Higher Education Institutions, globally. A study by Aguilera-Hermida (2020) found that college students' motivation, self-efficacy and cognitive engagement decreased after the COVID-19 transition and only the use of technology increased. A qualitative study investigated the challenges, difficulties and coping strategies and mechanisms of 106 students, during the COVID-19 pandemic, at the Nelson Mandela University Business School (BS) (Cullen et al., 2020). The thematic analysis used in the study included Theme Frequency and Association Diagrams (TFAD). The study found that the BS students (Figure 3) found studying online difficult and frustrating (n=33), challenging (n=27) and preferred face-to-face interaction (n=15). The challenges they faced included data costs, work commitments and working with family and children at home.

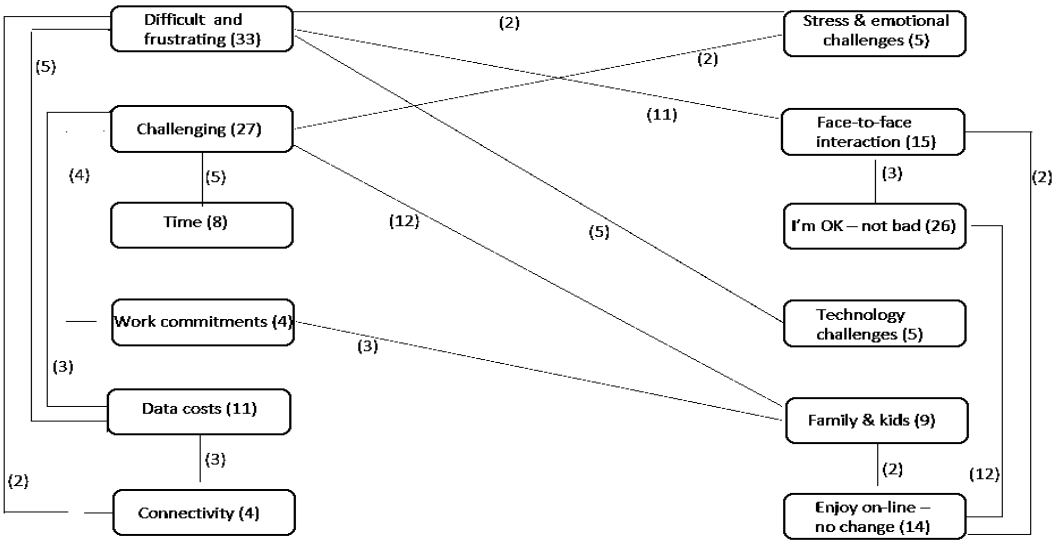

Figure 3: Studying online (Cullen et al., 2020).

The difficulties the students experienced (Figure 4) included technological (n=24), connectivity (n=20), data costs (n=17), missing face-to-face interaction (n=18) and library access (n=8). Working from a home environment, brought its own set of problems, having to deal with family and children (n=10), completing work activities and dealing with stress and emotional challenges.

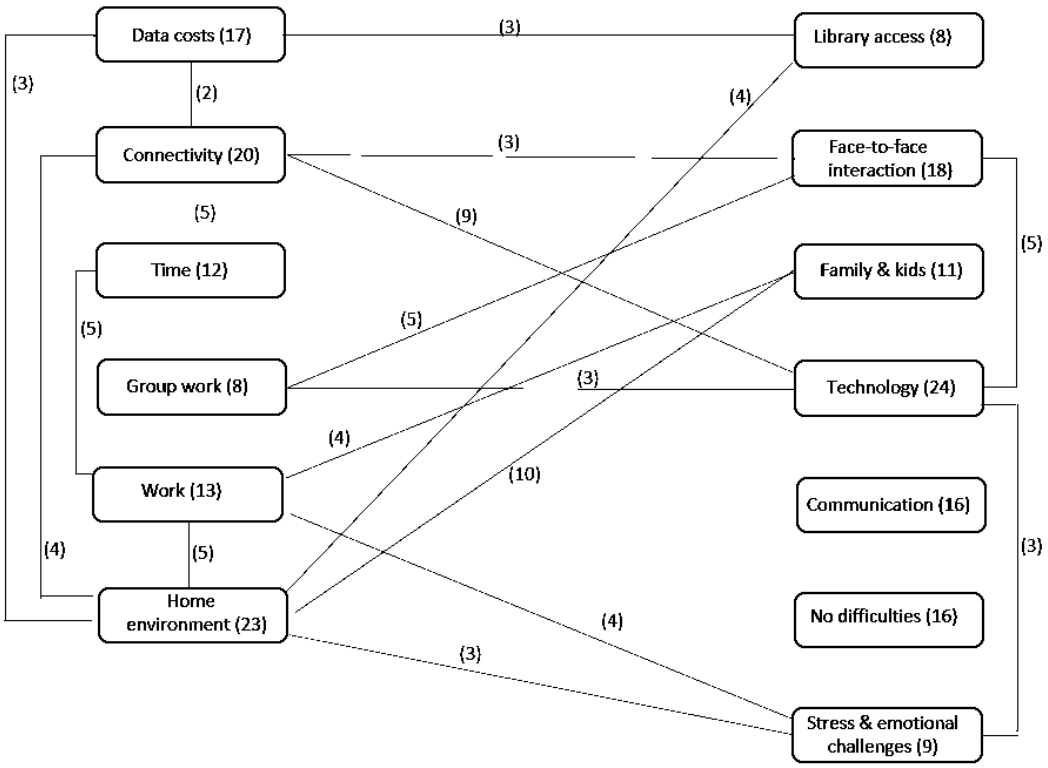

Figure 4: Difficulties experienced (Cullen et al., 2020).

The measures BS students put in place to keep abreast of their study requirements (Figure 5), included implementing a work schedule (n=54), buying data reserves (n=11) and working at night (n=10). The students further indicated that having a dedicated work environment at home was important.

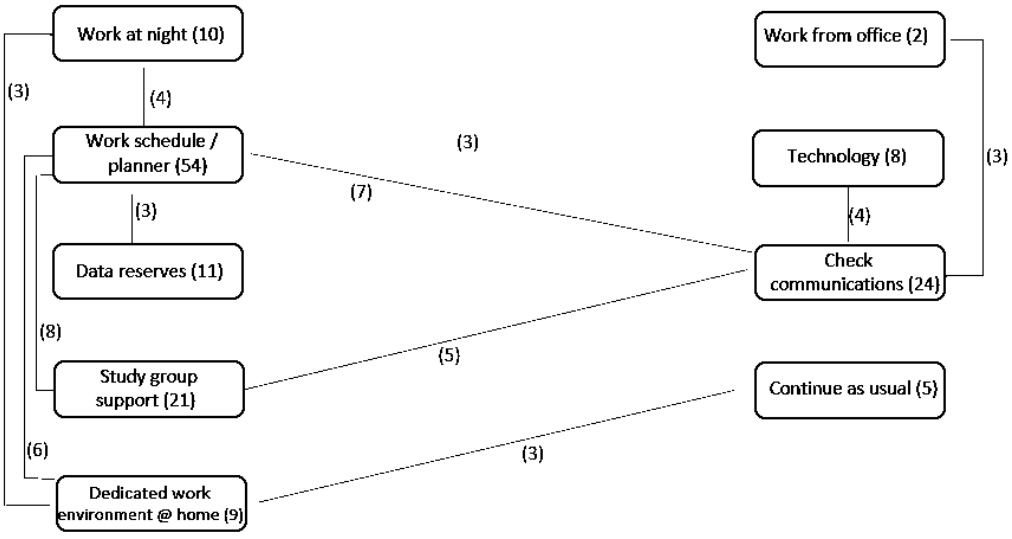

Figure 5: Measures put in place to meet study requirements (Cullen et al., 2020).

3.3 Teaching Programming and Blockchain

The discipline of Computer Science can assist with the wider challenges faced during the COVID-19 pandemic (Crick et al., 2020). Teaching computer programming in an online environment has had some benefits. The benefits include the use of modern teaching technologies and digital infrastructure at academic institutions (García-Salirrosas, 2020). Computing students generally experience a 'sense

of belonging' working with digital technologies. Mooney and Becker (2021) however found that computing students experienced stress and anxiety working remotely during the COVID-19 period and working remotely extremely challenging. Teaching students to write computer programmes has been acknowledged internationally, as a difficult task (Maltby, 2020; Settle et al., 2014). Online teaching and learning to write computer programmes are the relative new practices during the COVID-19 pandemic period and can be effective (Nordin, 2021; Maltby, 2020). Students however find it difficult and frustrating to acquire new programming knowledge and support in an online environment (Nordin, 2021). Peer reviews can be as effective as paid teaching assistance in programming courses (Settle et al., 2014). Students completing computer programming courses generally work in computer laboratories, with the assistance of peers and senior teaching students or paid assistants. Coding exercises can improve students understanding of Blockchain technology. Implementing a code-based method to teach Blockchain technology to accounting students was found to be feasible and instructive (Kaden, Lingwall, & Shonhiwa, 2021). In addition to using a code-based education methods in a Blockchain course, serious gaming methods have also been used. The game, Bloxxgame have been successfully used in a Blockchain course to teach students concepts and Blockchain operations, such as signing, creating transactions, block building, etc. during the COVID-19 pandemic period (Dettling & Schneider, 2020).

3.4 COVID-19 Impact on Programming-Based Courses

Online teaching and learning have become the new standard in education and have changed many lecturers' approaches to teaching. Teaching online means adapting course material from a face-to-face format to an online format. Support material provided includes PowerPoint lecture materials, voice-overs and video recordings of lectures. Technologies used in online teaching include Zoom, Microsoft Teams and Google Meet. Online in-class participation software such as Poll everyone or Padlet are used to create student interaction. However, a study by Saminathan and Hemalatha (2021) found that 80% of the fifty respondents were of the opinion that they experienced technical difficulties with online teaching tools. The study also found that 88% of the respondents were of the opinion that teaching and information sharing is more difficult in an online environment.

3.5 Honours Blockchain Course

The Honours Blockchain course is presented in the first semester of the Honours year (4^{th} year) and consists of a theoretical and practical component. The programming component of the course introduced students to a practical example of how a Blockchain can be implemented. Once the internal workings of a Blockchain have been programmed, the programming is then done on an established Blockchain, Ethereum. The students were taught how to think and program on a Blockchain by making use of smart contracts. The students were assigned several smart contracts to create increasing difficulty. Students were required to write small smart contracts in class as their practical exercises and were assigned a practical project after each class. The course finally required the implementation of a real-world project at the end of the course to be completed over a 6 week period. The technology used in the practical component was Ethereum and the programming language used was Solidity.

The assignments students had to complete, included:

1. Create a Blockchain from scratch in any appropriate programming language, the Blockchain was to support wallets, mining and transactions.
2. To create a smart contract for running a medical practice on a Blockchain. The medical practice had to be integrated into an association, which would handle malpractice claims, keep medical records of patients and vote on various issues from the association.
3. Create a smart-contract that facilitates buying and selling assets (properties) on the Blockchain. The students were tasked to implement a smart contract that would allow several

parties to add information to the Blockchain, but only the owner was allowed to move or sell the asset.

Smaller smart contracts were developed in class and included:

1. Running a bar tab in a restaurant;
2. Creating a banking system;
3. Creating a student management system.

The Blockchain project tasked the students to interpret and create a supply chain management based on Wagyu beef. The students were required to think about and create an entire supply chain management, which would keep track of Wagyu cattle, throughout their lifetime. The Blockchain had to store parental information, medical history and store all information from the birth of the cattle until they were slaughtered and the meat can be purchased in a store. The project requirements were stated relatively broadly to encourage practical thinking and original solutions.

4. Results

The qualitative data analyses were conducted using the annual anonymous course feedback forms completed by students that are compulsory for each course. The course evaluations focused on course content and presentation and included the lecturer teaching evaluations. The consensus over the 3 years was that the teaching aspect was excellent, the presenters were very knowledgeable, approachable and had a solid technical understanding of Blockchain programming. The course evaluations were thematically analysed and the results are presented below.

Over the past 3 years, 23 students completed the NMU Honours Blockchain course. Table 1 shows that the Honours Blockchain students were predominantly male (n=21) and included 7 Black, 3 Coloured and 13 White students. The citizenship of the total group was mainly South African (n=21) and 2 students were from Zimbabwe. The students mainly lived with their parents (n=20), specifically in 2020 during lockdown. Fifteen students were BSc Honours and 8 did a BCom Honours. All students had access to a computer and the Internet at the place where they lived.

Table 1: Group demographics

	2018	2019	2020
Gender			
Female	1	-	1
Male	11	8	2
Race			
Black	3	3	1
Coloured	2	-	1
White	7	5	1
Nationality			
South African	10	8	3
Foreigners	2	-	-
Place lived			
Parents	10	7	3
Residence	2	1	-
Degree			
BSc Hon	7	6	2
BCom Hon	5	2	1

All the students found the new Blockchain course, specifically the programming component technical, challenging and time consuming (Figure 6). They indicated that the lecturer, presenting the programming component had “excellent practical knowledge”, “practical industry experience” and

was “passionate about the subject”. The lecturer was “very helpful and went an extra mile to ensure students understand the course”. Sixteen students found the new Blockchain programming environment “difficult and frustrating”, spending a long-time programming and implementing Blockchain applications and contracts. Twenty-two students indicated they liked working with *new technologies* and being at the ‘*cutting edge’* of software development (n=16). The students further indicated that “learning new terms and programming languages are good for my future career”; “coding in Solidity is an excellent new skill” and the course “provided great insight into new developments in Computer Science”. The students generally found the course “excellent and very enjoyable”. The 2020 students were “surprised that more students did not do the course”.

The pre-COVID-19 group (2018-2019) experienced fewer difficulties, having face-to-face lectures and practical sessions on campus with expert academic assistance during practicals (Figure 7).Being in the Honours lab, they had access to peers and lecturer assistance. They did experience some difficulties working at home with access to software and powerful computer equipment. The 2020 group indicated they had limited face-to-face access to academic Blockchain programming expertise and support, including peer expertise and support working from home. They had to rely more on Internet Blockchain forums, watch YouTube videos and access Blockchain support websites and blogs.

Stress amongst students is multifactorial, arising from both academic and non-academic factors, including socio-cultural, environmental and psychological attributes (Brand & Schoonheim-Klein, 2009). The lockdown meant that the Honours students in 2020 had higher data costs and two experienced emotional and stress related challenges.

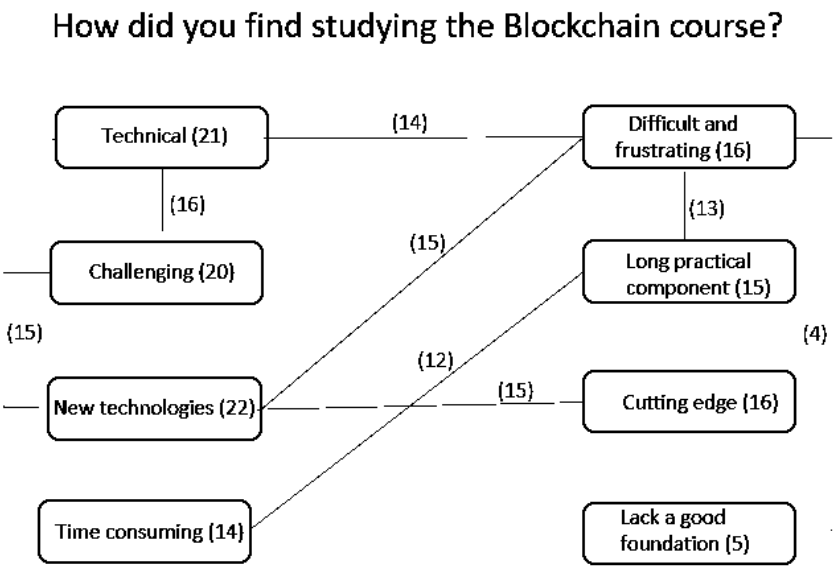

Figure 6: Studying Blockchain course

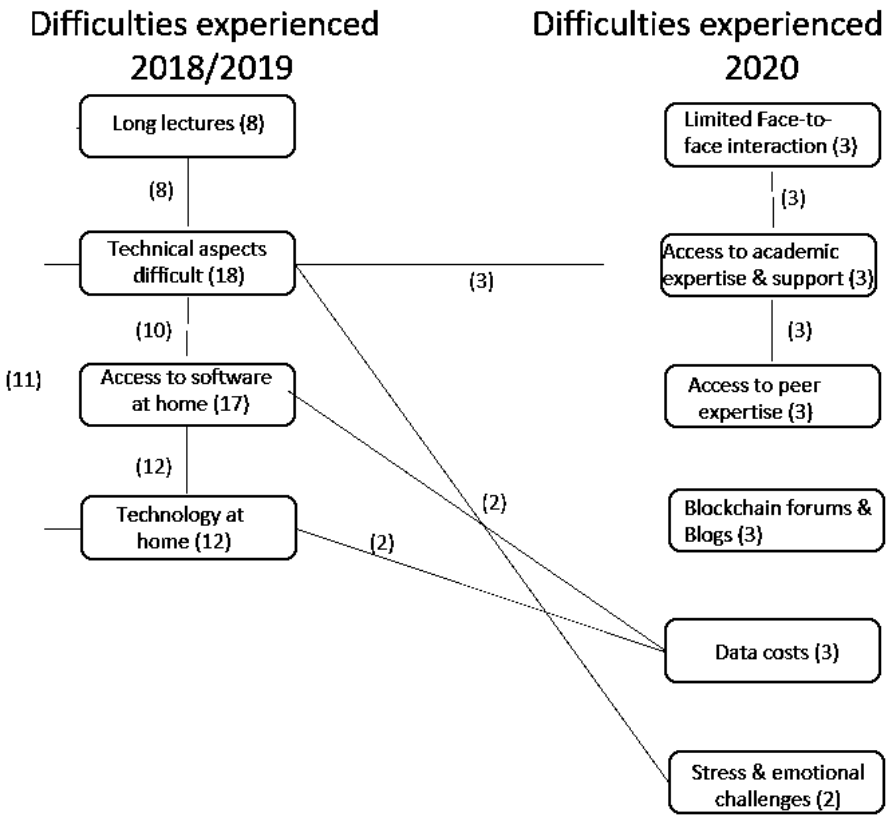

Figure 7: Difficulties experienced

The improvements suggested by the pre-COVID-19 group included that lectures were too long and they wanted shorter lectures (n=8), longer, compulsory practical sessions (n=16) and eleven students wanted access to the Blockchain software at home (Figure 8). The 2020 group included improvements to the course that related to the national lockdown and having to work from home. They wanted more virtual academic support, specifically when coding. They relied on Blockchain forums, support websites and blogs and missed the face-to-face support during practical sessions. They indicated that their project took much longer to complete than students in previous years, due to limited face-to-face academic programming support. The 2018/2019 students suggested that the lectures, usually 4 hours with breaks be "split up into two lectures per week".

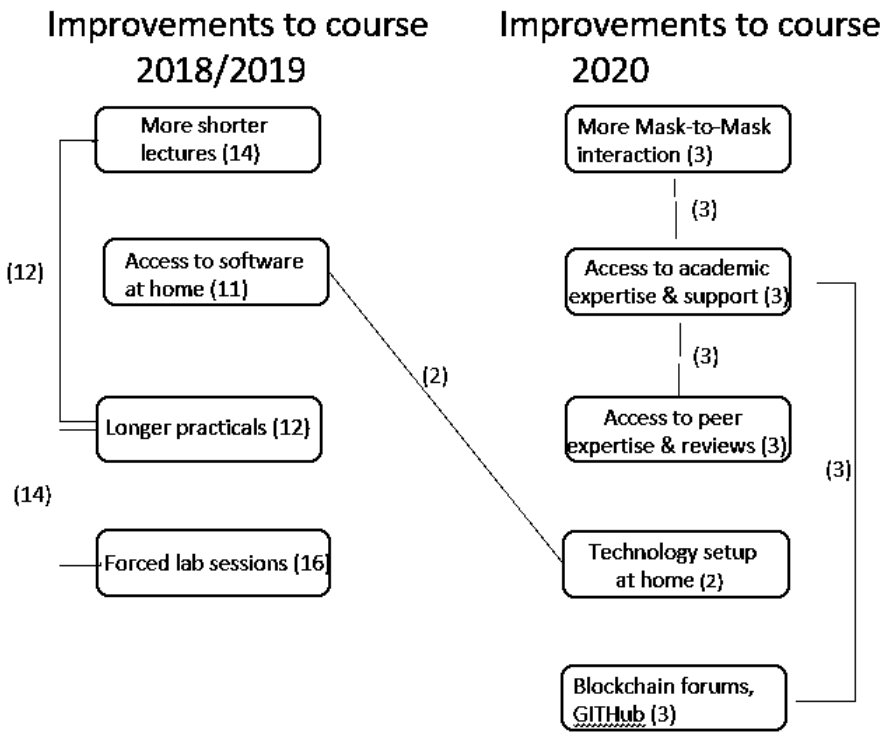

Figure 8: Improvements to the course

The lecturer presenting the programming Blockchain component made the following observations:

- There was a clear distinction between the 2018-2019 group and the 2020 group. The 2018-2019 group had a very theoretical experience. Questions asked were theoretical in nature. The questions focused on structure and syntax. Questions were more focused on a good way or more efficient way to achieve possible solutions. When the assignment was given to the students, because of the highly theoretical interest in the technology, the 2018-2019 group had a lot of problems when independent thinking was involved. Students struggled to design a solution and implement the practical part. Difficulties were encountered from the setup, to the understanding, to the modelling, to the end product.
- The 2020 COVID group raised COVID-19 in conversation several times. Questions asked by the 2020 group were much more hypothetical in nature and thus more practical. Questions ranged from new ways to do banking and insurance, to gambling and contact tracing. It was clear that the students could immediately think of applications for Blockchain, given the situation everyone was exposed to. Students had more interest in what is possible and what is not possible with little interest in actual structure and syntax. The 2020 group had a clear interest in the security that a Blockchain has to offer and unlike the 2018-2019 group, the 2020 group made a greater effort to understand the problems of security. The 2020 group had very few difficulties with the conceptual or independent thinking. The 2020 group had reference problems. The nature of a Blockchain is highly technical with a few programming resources available. With fewer people to ask for help, the 2020 group struggled to find resources to assist with implementing the ideas that they had.
- The skills that the 2018-2019 students obtained were more geared towards a theoretical understanding of Blockchain. The 2020 students were more geared towards the application of Blockchain. Both groups gained sufficient knowledge in all areas of a Blockchain.

- The 2020 group had the drawback of very few resources and very little help. With a highly technical topic and very few resources available, all projects took longer than anticipated and gave more problems than expected. The benefits that the group had was that they became much more accustomed to modelling a problem correctly and implementing a practical solution to a problem.
- It is our opinion that the students of 2020 were given a much closer and better insight as to how industry would work. The 2020 group received a much more practical and research oriented exposure. A 2020 student would find it easier to design a solution for a problem, whereas a 2018-2019 student would be more suited to implementing the solution. The 2020 students gained a better understanding of a consultancy type of environment, where the 2018-2019 students gained a better understanding of a programmer environment.
- Certain skills that the 2020 group gained are more valuable than those of the 2018-2019 group. Understanding application and business sense in a project is a skill that is difficult to learn and impossible to learn from textbooks. All Computer Science students would be much better suited for industry if they were pushed in a similar direction, as industry rarely works according to the books or theoretical best practices.

5. Conclusion

The education sector presently faces great challenges and uncertainty; academics need to find innovative ways to present challenging programming orientated courses. The COVID-19 pandemic has changed the teaching methods academics were accustomed to and the choice of teaching methods should be based on pedagogic research providing proof that the chosen method enhances the learning in a specific course (Shaaban, 2021). Academics have unfortunately not had the time to choose suitable teaching methods and were forced to use the tools and methods provided by the relevant institutions.

Research has shown that the students were generally negatively affected by the lockdown, found the situation stressful, difficult and frustrating at times and experienced problems with data costs, connectivity and the use of new technologies (Cullen, et al., 2020). The challenges faced by students in developing countries included poor national infrastructure, lack of resources and reduced student-lecturer engagement (Oyedotum, 2020).

Teaching and information sharing is regarded more difficult in an online environment (Saminathan & Hemalatha, 2021). Learning to write computer programmes is a difficult task and various educational guidelines and practices exist for on-site presentation (Settle et al., 2014). Students studying programming-oriented courses, such as Blockchain, face additional challenges and difficulties during the COVID-19 lockdown, due to working remotely with limited academic support. The Honours students completing the Blockchain course in this study, found the course technical, challenging and time-consuming. Students, learning to programme, prefer face-to-face lectures and the least advantageous aspect of online lectures was the ability to assimilate difficult concepts (Maltby, 2020). Students completing the Blockchain course pre-COVID-19, found the programming component “difficult and frustrating” and requiring ‘long practical sessions’ using new technologies, such as programming in Solidity on the Ethereum platform. The 2020 class, during the COVID-19 lockdown period, experienced additional difficulties, including limited access to academic expertise and support, access to peer expertise and assistance, experience high data costs and experiences stress and emotional challenge. García-Salirrosas’s (2020, p. 41) study also indicated that students experienced “a lot of stress and anxiety”. They had to rely on Blockchain forums and blog sites for help and missed practical face-to-face sessions, where academic expertise was readily available for assistance with programming related problems. Overall, the students found the course “very good and full of insight and relevance”. This research study has given insight into presenting a programming oriented Blockchain course on-line, with an important practical component. The Blockchain lecturers however,

indicated that students were experiencing a real-world industry situation, where academic assistance were not readily available and programmers have to rely on forums on the Internet for assistance. The limitations of this study were a relatively small sample size of the Blockchain 2020 course and the inclusion of respondents from one department. Related research indicated that specialised tools developed for teaching computer programming help in motivating students and allowed students to perform better in programming tasks (Chakraverty & Chakraborty, 2021). Future research will include investigating tools to assist in teaching programming in an online environment. Future research will address the issues and improvement suggested by the students and investigate using collaborative code-sharing technologies such as GitHub, Slack and CodeAnywhere.

6. References

Aguilera-Hermida, A. P. (2020). College students' use and acceptance of emergency online learning due to COVID-19. *International Journal of Educational Research Open*. Online. https://doi.org/10.1016/j.ijedro.2020.100011

Alammary, A. (2020). Blended learning models for introductory programming courses: A systematic review. *PLoS ONE*, 14(9), e0221765. https://doi.org/10.1371/journal.pone.0221765

Brand, H. S., & Schoonheim-Klein, M. (2009). Is the OSCE more stressful? Examination anxiety and its consequences in different assessment methods in dental education. *European Journal of Dental Education*, 13(3), 147-153.

Chakraverty, S., & Chakraborty, P. (2021). Tools and Techniques for Teaching Computer Programming: A Review. *Journal of Educational Technology Systems*, 49(2), 170-198. https://doi.org/10.1177/0047239520926971

Crick, T., Knight, C., Watermeyer, R., & Goodall, J. (2020). The Impact of COVID-19 and "Emergency Remote Teaching" on the UK Computer Science Education Community. UKICER '20, September 3–4, 2020, Glasgow, United Kingdom, 31-37. https://doi.org/10.1145/3416465.3416472

Cullen, M., Calitz, A.P., Jooste, C., & du Plessis, M.C. (2020). Business School students' challenges and coping strategies during the COVID-19 pandemic. Digital 2020 Conference, 3-4 December 2020, Durban, South Africa, 192-209.

Daniel, J. (2020). Education and the COVID-19 pandemic. *Prospects*, 49, 91–96. https://doi.org/10.1007/s11125-020-09464-3

Dettling, W., & Schneider, B. (2020). Bloxxgame – A Simulation Game for Teaching Blockchain. In: Marfisi-Schottman I., Bellotti F., Hamon L., Klemke R. (eds) Games and Learning Alliance. GALA 2020. Lecture Notes in Computer Science, 12517. Springer, Cham. https://doi.org/10.1007/978-3-030-63464-3_16

Di Pietro, G., Biagi, F., Costa, P., Karpinski, Z., & Mazza, J. (2020). The likely impact of COVID-19 on education: Reflections based on the existing literature and recent international datasets. JRC Technical Report. European Commission.

García-Salirrosas, E.E. (2020). Satisfaction of university students in virtual education in a COVID-19 scenario. In 2020 3rd International Conference on Education Technology Management (ICETM 2020), December17–19, 2020, London, United Kingdom. ACM, New York, NY, USA, 41-47. https://doi.org/10.1145/3446590.3446597

Kaden, S., Lingwall, J., & Shonhiwa, T. (2021). Teaching Blockchain through Coding: Educating the Future Accounting Professional. *Issues in Accounting Education*. https://doi.org/10.2308/ISSUES-19-080

Maltby, J. R. (2020). Learning Programming Online: Student Perceptions and Performance. 37th

ASCILITE 2000 Virtual Conference. Retrieved 1 July 2021 from https://ascilite.org/conferences/coffs00/papers/john_maltby.pdf.

Mooney, C., & Becker, B.A. (2021). Investigating the Impact of the COVID-19 Pandemic on Computing Students' Sense of Belonging. *ACM Inroads*, 12(2), 38-45.

Nordin, N. (2021). The Effectiveness of Learning Programming Language Online: Student Perceptions and Performance. *Journal of Technology and Operations Management,* 16(1). https://doi.org/10.32890/jtom2021.126.1.3

Oyedotun, T. D. (2020) Sudden change of pedagogy in education driven by COVID-19: Perspectives and evaluation from a developing country. *Research in Globalization*, Online. https://doi.org/10.1016/j.resglo.2020.100029

Rapanta, C.,Botturi, L.,Goodyear, P., Guardia, L., & Koole, M. (2020). Online University Teaching During and After the Covid-19 Crisis: Refocusing Teacher Presence and Learning Activity. *Postdigital Science and Education*, 2, 923–945. https://doi.org/10.1007/s42438-020-00155-y.

Saminathan, R., & Hemalatha, P. (2021). Teaching Online – A Challenge To Senior Academicians. Retrieved on 11 March 2021 from https://www.researchgate.net/profile/Dr-r-2/publication/349761470_TEACHING_ONLINE_-A_CHALLENGE_TO_SENIOR_ACADEMICIANS/links/604092234585154e8c752f76/TEACHING-ONLINE-A-CHALLENGE-TO-SENIOR-ACADEMICIANS .pdf

Saunders, M., Lewis, P., & Thornhill, A. (2019). Research Methods for Business Students (8th ed.). Edinburgh Gate, Harlow: Pearson Education Limited.

Settle, A., Vihavainen, A., & Miller, C. S. (2014). Research Directions for Teaching Programming Online. The International Conference on Frontiers in Education: Computer Science and Computer Engineering (FECS'14), Las Vegas, Nevada, USA, 21 -24 July 2014.

Shaaban, I.G. (2021). Learning Theories, Learning Styles and Teaching Strategies. University of West London. Retrieved on 11 March 2021 from https://www.researchgate.net/profile/Ibrahim-Shaaban-3/publication/339004379_Learning_Theories_Learning_Styles_and_Teaching_Strategies/links/5e38954da6fdccd965846855/Learning-Theories-Learning-Styles-and-Teaching-Strategies.pdf

Sheng-Bo Huang, S-B., Jeng, Y-L., & Lai, C-F. (2021). Note-Taking Learning System: The Use of the Learning Style Theory and the Peer Learning Method on Computer Programming Course. *Journal of Educational Computing Research*, 1-26. https://doi.org/10.1177/0735633120985235

Smith, N., & Barret, E. (2020). Coping with life in isolation and confinement during the Covid-19 pandemic. The Psychologist.

Sprang, G., & Silman, M. (2013) Posttraumatic stress disorder in parents and youth after health-related disasters. *Disaster Medicine and Public Health Preparedness,* 7, 105-110.

Trach, E. (2018). Asynchronous Learning: Definition, Benefits and Example Activities. Evolving Ed. Schoology Exchange.

University of Auckland. (2020). Thematic analysis – a reflexive approach. Retrieved 10 July 2021 from https://www.psych.auckland.ac.nz/en/about/thematic-analysis.html.

Wittmann-Price, R. A., & Price, S. W. (2018). Educational Theories, Learning Theories, and Special Concepts. In Review Manual for the Certified Healthcare Simulation Educator, 2nd Ed.

Application of Digital technologies in the 21st Century. Literature Review of Experiences, Opportunities and Challenges in Higher Education

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Abstract
This study aimed at designing a framework to be adopted when implementing digital technology in Higher Education Institutions (HEIs) in Oman. This study is guided by an interpretivism research philosophy. This philosophy uses a qualitative research design that is interpretivism in nature. The design adopted the use of content analysis as the major research instrument. This study used search engines like Google Scholar, Google Advanced Search, Research Gate, and Masader as the key secondary data sources for the study. Literature related to online books and other academic blogs was also be explored. Literature review unpack the discourse related to digital technologies that are ideal for HEIs learning. Additionally, study identifies the appropriateness of the different digital technologies for use in HEIs in Oman. The secondary research objectives include "to identify opportunities that are presented by digital technology in HEIs, to establish challenges that are faced when using digital technology as a teaching and learning tool in HEIs and establishing methods of implementing digital technology in HEIs at the most cost-effective and efficient manner". The period of search was limited to a decade, that is, from 2011 to 2021. The academic research journals are categorized into different study areas which are in line with the research objectives. Thematic analysis was conducted, and themes or areas of interest were determined by saturation. The study results broadened the scope and understanding of digital technologies that were used before and after the new normal. The study outlined the needs analysis for both the teachers and the students operating during this period. Results of the study were identified research gaps and contributed to the body of knowledge through the identification of digital technologies that are applicable in HEIs.
Keywords: Digital technology, higher education institutions, challenges and opportunities of digital technology.

1. Introduction

For approximately the past half a century (1980-2020), digital technology has been used in higher education institutions (HEIs) to enhance the teaching and learning processes admittedly in different forms and for specific purposes (Nava, 2020). Daily life has been affected adversely by the digital revolution in areas such as shopping (online shopping facilities), reading (online digital material), and finding directions using global positioning system (Anderson, 2016; Smith & Anderson, 2016; Zickur & Raine, 2014) and the education sector has not been left out in this exodus. This observation was raised by Schindler et al., 2017) reiterate that integrating digital technology into teaching and learning is not a new development and challenge for HEIs. As early as nineteenth century, administrators and faculty

have grappled how to effectively use technical innovations such as videos and audio recordings, electronic mails and teleconferencing to augment or replace traditional instructional delivery methods (Kaware &Sain, 2015; Westera, 2015).

The initial tools used by colleges to interact with students were electronic mails (e-mail), YouTube, Google, and other search engine which required worldwide web (www) connections. This approach to teaching gave birth to blended learning in which teachers/instructors would interact with students using both traditional face-to-face approach and the online teaching and learning methods. Information communication technology (ICT) was incorporated in the teaching and learning field to provide more effective teaching which was believed to bring more effective learning (Nava, 2020). Effective learning would be attained by means of allowing student to refer back to the online teaching material they would have been given such as videos, soft copies in the form of word documents, power point presentations and any material that could be forwarded to learners. Additionally, learners would access these sources of learning at their own convenience.

Advanced and continued push for the use of digital technology at HEIs has been advocated by researchers even though some researchers still argue that the traditional teacher-centered instruction is still superior to online learning (Nava, 2020). No grounded explanation has been advanced to support the claim why digital technology works well in some cases, yet it fails to produce positive results in other instances. However, generally the mushrooming of digital technology cannot be denied and the fact that it is making life easier by the day for both the instructor and the learner more so in its different forms. There is a diverse approach to the implementation and treatment of digital technology and there has been no studies to associate failure or success of students to any digital technology that might be used by institutions of higher education (Nava, 2020).
The questions that the literature review process hopes to answer are:

1. What are the digital technologies that are ideal for use by selected HEIs?
2. What are the opportunities that may be presented by different digital technologies that may be used by selected HEIs?
3. What are the challenges faced by selected HEIs, when using digital technology?

2. Literature Review

Rice (2003) define digital technologies as a wide range of technologies, tools, services and applications that use different types of hardware and software. The purpose of these technologies is to facilitate service provision and activities using electronic means for the creation, storage, processing, transmission, and information display. Rumanyika and Galan, (2015) posit that the work done by digital technologies at HEIs includes developing course content, sharing and delivering the same course content using techniques such as power point presentations, communication between learners, instructors, teachers as well as the world outside their immediate environment, academic research, and administrative support including student enrollment. It is important to get clear definitions of phrases related to digital technology. The table below gives a forwarded summary of several definitions of these phrases:

Table 1: Terminology and common definitions of Digital Technology

	Author(s)	Definition	Remarks/commend
1	Wade (2019)	Digital Technology is fundamentally about change, and it involves people, processes, strategies, structures, and competitive dynamics.	It is an all-encompassing process which requires active participation.
2	Riemer *et al.,* (2019)	Digital disruption is defined as the changes facilitated by digital technologies that occur at a pace and magnitude that disrupt established ways of value creation, social interactions, doing business and more generally our thinking.	Pace and magnitude are important for the transformation
3	Zhao, *et al.,* (2020)	The realignment of, or new investment in, technology and business models to engage digital customers more effectively at every touch point in the customer experience lifecycle. Companies needed to think of DT as a "formal effort to renovate business vision, models, and investments for a new digital economy.	Meeting digital customers at their point of need and brings about re-engineering of business processes, be it service environment or manufacturing.
4	Benavides *et al.,* (2020)	DT goes well beyond de-materialization of processes, encompassing an innovative use of new technologies (cloud, social, mobile, and analytics) to promote new services, re-define business models, and innovative interactions with its users.	Taking advantage of latest developments like cloud computing is important in HEI environments. Content creation is vital.
5	Benavides *et al.,* (2020)	DT of the university education system should have a broader focus and must include the	While embracing DT, it is important to think about the infrastructure and

			modernization of corporate IT architecture management, which could provide an important contribution to structuring the efforts of innovation in education.	curriculum and subsequently match them.
6		Benavides *et al.,* (2020)	The modern developments in the area of modernizing educational system with the aid of ITC technology and applied process thinking principles in the attempt to capture and model interrelated activities required to integrate digital technologies in teaching, learning, and organizational practices.	Design of curriculum should consider learning outcomes and the available infrastructure.
7		Benavides *et al.,* (2020)	DT is an accelerated evolution. It is also revolution because of its radical and structural implications for people as for infrastructure that also requires new educational and business models.	Like any other business facets, DT is radical if it must remain valid.
8		Benavides *et al.,* (2020)	Digital business transformation can be defined as the modification of business processes, procedures, capabilities and policies to take advantage of the changes and opportunities presented by new digital technologies, as well as the impact they have on society, while always thinking about current and future trends.	Opportunities must be quickly embraced while still being futuristic.

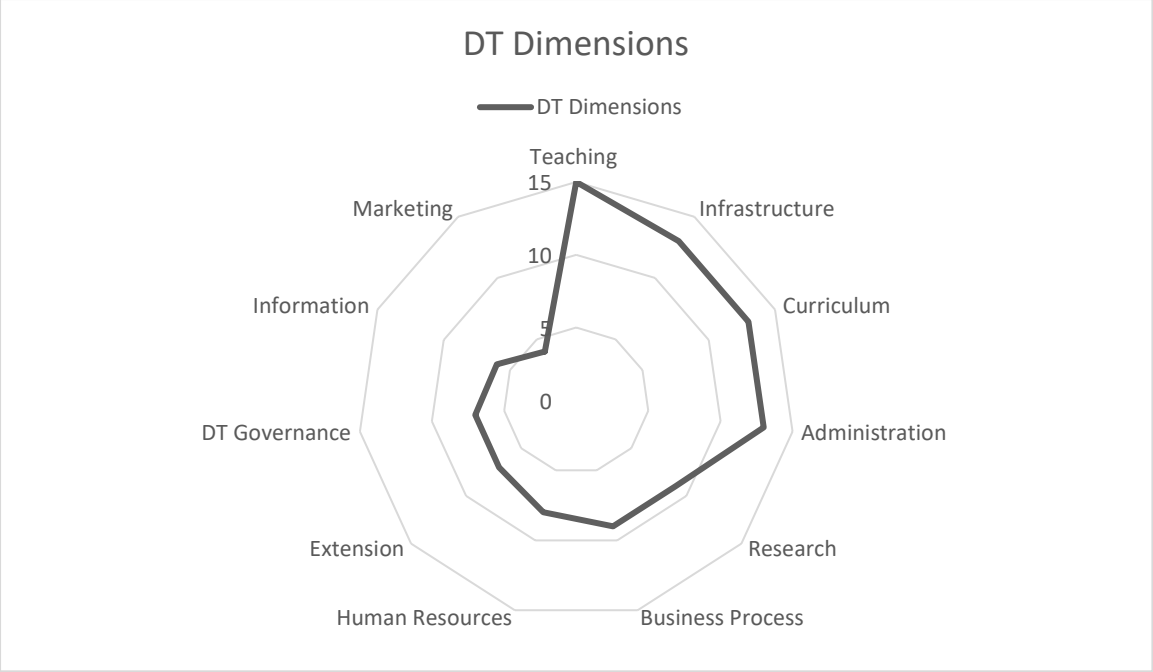

Figure 1: Radar of DT Dimensions in HEIs (Adapted from Benavides et al., {2020})

Benavides et al., (2020) posit that synchronization of the concepts that have been defined in Figure 1 above are represented by the nodes, and the relationship that exist between them are represented by their closeness to each other as well as the edges. Furthermore, frequency of appearance of the concepts in the analyzed articles is shown by the thickness and intensity of the color. Grab *et al.,* (2019) reiterate that digital technology is an element disruptor that fundamentally changes industries and organizations. The recent pandemic Covid-19 has forced HEIs to move to digital technology and has seen some disruptions which have brought some awakening to both the learners and the institutions of higher education. Bresinsky and Von Reusner (2017) urge that digitalized organizations need to focus on both technology and social domain for a successful transformation. HEIs must think of the technology they are to embrace both hardware and the software. Neglecting any of these two sides of technology might leave other learners out and bring disastrous results.

2.1 Classification of Digital Technologies

A wide range of technologies have been suggested by researchers include mobile phones, personal computers, tablets, digital televisions, radios, robots and so on (Vourikari *et al.,* 2016). Yet other researchers have promoted video conferencing, teleconferencing, distance learning (Moore *et al.,* 2011; Moore & Kearsley, 2011), mobile learning (Gikas & Grant, 2013), e-learning (Moore *et al.,* 2011), Masive Open Online Courses (MOOCs) (N'ambi & Bozalek, 2015) and Blended learning (Porter *et al.,* 2014).

2.2 Challenges Faced by HEIs when using Digital Technology

As early as two decades ago, indications were already there that the idea of adaptation of digital technologies was being advanced with researchers like Beebe (2004) stating that the adaptation of digital technologies in education would pave way for new pedagogical approaches in which learners would be expected to play a more active role than previously envisaged, simply referred to as self-directed learning. Nevertheless, irrespective of these massive preparations and research, some academicians still claim that the degree of uptake is low (Lwoga, 2012; Ssekakubo *et al.,* 2011; Oye *et al.,* 2011) propose that interrelated but complex system of factors create barriers for the adoption of digital technologies, and these include high cost of infrastructure, socioeconomic and technological

conditions, lack of a systematic approach to teaching and learning, awareness/education and attitudes towards digital technologies, technical and administrative support, staff development both teaching and support, and lack of expertise in the use of digital technology.

Using digital technology in higher education institutions is neither an automatic guarantee that students/ leaners will be actively engaged (Kirkwood, 2009) nor an assurance that high scores will be obtained (Tamin, *et al.,* 2011) because learners, instructors, and the society require skills and active participation (OECD, 2015a, 2015b). This was echoed by researchers (Englund *et al.,* 2017; Kirkwood, 2009; Kirkwood & Price, 2005; Ng, 2012, OECD, 2018a) who said that pedagogical competence of teachers in the use of digital technology is vital and others (Choi *et al.,* 2018, Redecker, 2017) who proposed the inclusion and modelling of good digital citizenship. The assumption that experienced teachers are better than novice teachers has been proved wrong (Englund *et al.,* 2017) as the latter group have been found to be more adept at rapid change and development. Additionally, research has pointed out that lack of digital skills is an inhibitor to using more educational technology in the classroom over and above systematic problems such as access to technology and workload, (Jaaskela *et al.,* 2017; Marcelo & Yot-Domingues, 2018; Margaryan *et al.,* 2011).

2.3 Opportunities presented using digital technologies in HEIs environments

Teaching and learning in higher education environment has been enhanced by digital technology which has become part and parcel of the learning process (Becker *et al.,* 2017; Bullen & Morgan, 2015). Research shows that digital technologies have had an exponential use at both the pedagogical and organizational level bring about some notable expectations of transformations in educational circle involving physical space and the methods of interaction and delivery of educational content (Pedro *et al.,* 2018). The roles of instructors and learners have changed and there has been equitable access to higher education (Henderson *et al.,* 2017). For instance, learners have been encouraged to be self-directed in the learning process (Vazquez-Cano *et.al,* 2015) greater access to learning material has been achieved making the learning process more effective (Han & Shin, 2016). Digital technologies such as Web 2.0 have been game changers simply because they have accorded support to students in their everyday life and have enhanced the support for learning thus advancing students' autonomy in learning (Neira, *et al.,* 2017; Norman *et al.,* 2013; Sleeman, Lang, & Lemon, 2016). There has been flexibility regarding the time that the instructor and the learner interact which has gone beyond the classroom walls for purposes of connectivity and communicating, sharing learning content and engaging learners (Pinto & Leite, 2020).

The use of synchronous and asynchronous technologies has made it possible to collaborate and support the learning process (Aresta *et al.,* 2015), bring discussions and knowledge sharing on board. Redesigning of the learning space has been achieved that has seen physical laboratories for experiments being replaced by virtual and augmented reality (Carbonell, Carrera & Bermejo Asensio, 2017, Dubovi *et al.,* 2017; Kingston et al., 2012) or the use of simulation-based laboratories (Balakrishnan & Woods, 2013; Estriegana *et al.,* 2017).

3. Methodology

This research employed a systematic literature review by adopting three pivotal activities to achieve its objectives. These activities were the identification and a thorough critical review of the appropriate researches, followed by a synthesis of the research findings into comprehensive statements (Singh & Thurman, 2019). This was backed by the interpretivism research philosophy (Cuthbertson, Robb & Blair, 2020; Lovino & Tsitsianis, 2020). Additionally, the study adopted the configurative review as a major systematic research methodology as opposed to the aggregative review. Using the configurative review, data from the sampled studies were configured to respond to the review questions (Bozkurt *et al.,* 2017; Gough, Oliver, & Thomas, 2012). This study aimed to respond to the following research questions:

1. What are the digital technologies that are ideal for use by selected HEIs in Muscat, Oman?
2. What are the opportunities that may be presented by different digital technologies that may be used by selected HEIs in Muscat, Oman?
3. What are the challenges faced by selected HEIs in Muscat Oman, when using digital technology?

The researchers conducted thematic analysis and themes or areas of interest were determined by saturation. This analysis assisted in ascertaining patterns of implications across a dataset responsible for answers to the rresearch questions under consideration (Cuthbertson, et al., 2020). Furthermore, content analysis was adopted due to its aptitude to produce systematic and quality literature review studies. This content analysis assisted in ascertaining and summarising developments in the existing literature. The researchers decided to adopt it so as to gain its methodological merits above other research methods (Gaur & Kumar, 2018; Moldavska & Welo, 2017; Bozkurt, Akgün-Özbek & Zawacki-Richter, 2017).

3.1 Sampling

A choice of articles was performed by using the keywords which included 'computer technology, computer-aided instruction, computer-aided teaching and learning and digital technology'. Many academic databases were used but search engines like Google Scholar, Google Advanced Search, Research Gate, and Masader were used as the key secondary data sources for the study. More so, online books and other academic blogs were also reconnoitered. Academic research journals were categorized into different study areas which are in line with the research objectives.

3.2 Data Collection

During data collection, recurring articles were deleted from the list and only articles published in peer-reviewed journals and written in English were considered. The study period was limited to a decade, that is, from 2011 to 2021. The focus of the data collection was to have data which will assist in the designing of a framework to be adopted when implementing digital technology in Higher Education Institutions in the post 21st century. Data acquired was structured in the form author(s) definition, remarks/commend, findings, scope and conclusion. Themes were identified from the studies and synchronized to represent the literature-based finding of the research.
The remaining sections focused on a detailed discussion showing the findings using content analysis.

4. Results and Discussion

4.1 What are the digital technologies that are ideal for use by HEIs?

According to Vourikari et al., (2016) the most common digital technologies that are ideal for use by HEIs includes mobile phones, personal computers, tablets, digital televisions, radios, robots. Besides these, there are also other digital technologies that have gained prominence, the likes of video conferencing, teleconferencing, distance learning, mobile learning, e-learning, Massive Open Online Courses (MOOCs) as well as and blended learning (Moore *et al.,* 2011; Moore & Kearsley, 2011; Gikas & Grant, 2013; N'ambi & Bozalek, 2015; Porter et al., 2014). Furthermore, digital technology can be synchronous e-learning comprising of physically dispersed learners gaining access to the same web site concurrently with the instructor or asynchronous e-learning, which is not instantly received by those involved and is normally aided by internet communications media like e-mail or discussion boards.

This study suggests that it is high time for all the HEIs to fully embrace digital technology in its operations (Bresinsky & Von Reusner, 2017; Grab *et al.,* 2019). It must be flexible to have both synchronous and asynchronous communication tools. This will curb against leaving other learners out of the racket and also avoids bringing out terrible results. However, these digital technologies must

earn the support of faculty members or students. There must also be multi-purpose and simple in order to inspire students to collaborate with one another, sharing personalized response products.

4.2 What are the opportunities that may be presented by different digital technologies that may be used by HEIs?

Literature review has proved that we are now living in a 'new normal' where technology is evolving very fast. Definitely, a new song requires a new dance, same applies with the teaching and learning process in HEIs which now requires digital technology as an absolute necessity. In other words, the teaching and learning processes in HEIs are now completed with digital technology (Becker e*t al.,* 2017; Bullen & Morgan, 2015). Such a technology has proved to be ideal for use in HEIs due to its excellent ability to save costs in the long run (Pedro, Barbosa & Santos, 2018). It requires less physical space and it provides a comprehensive interaction and content delivery system between the educator and the student. More so, its ability to offer equitable access to higher education is highly commendable (Henderson, Selwyn & Aston, 2017). Digital technology assists in achieving Sustainable Development Goal 4 (SDG 4) which focuses on 'ensuring an inclusive and equitable quality education and promoting lifelong learning opportunities for all'. This is a great opportunity which must be grabbed by HEIs.

The learning process has become more effective by creating a platform in which students can access a lot of learning materials and stimulate their learning to self-drive process (Vazquez-Cano, *et al.,* 2015; Han & Shin, 2016; Neira *et al.,* 2017; Norman, *at al.,* 2013; Sleeman, *at al.,* 2016). Indeed, digital technology has evolved students' autonomy in learning with Web 2.0 for example, being predominantly supportive when aligned to teaching and learning. The Web 2.0 tools have accorded students an opportunity to collaborate with classmates as they share their knowledge with a wider audience around the world (Pinto & Leite, 2020).

Research has also concluded that digital technology has created flexibility regarding interaction time between the instructor and the learner which has gone beyond the classroom walls (Aresta *et al.,* 2015; Carbonell, *et al.,* 2017, Dubovi, *et al.,* 2017; Kingston et al., 2012). This digital system has restructured the learning space such that physical laboratories for experiments have been replaced by virtual and augmented reality or the use of simulation-based laboratories which may be advantageous in terms of cost and time saving (Balakrishnan & Woods, 2013; Estriegana-Valdehita, *et al.,* 2017).

This research therefore advice HEIs to embrace digital technology as a matter of urgency in order to grab the opportunities which are posed by this system of technology. HEIs must be optimistic in implementing this technology. Of course, it may appear unworthy or expensive but in the long run, it will likely yield positive results. A green light lies ahead of the dark tunnel. This world is now a technological world, like it or not.

4.3 What are the challenges faced by HEIs when using digital technology?

From the researchers conducted, it is sad to epistle that digital technology is associated with several challenges. Beebe (2004) has long indicated that the use of digital technology in the teaching and learning process entails an adoption of new pedagogical approaches in which learners would be expected to play a more active role than previously envisaged. This is simply referred to as self-directed learning. Nevertheless, a large number of scholars agree on the view that there still exists a complex structure of factors which create obstacles to successfully implement digital technologies in HEIs (Marcelo & Yot-Domingues, 2018; Jaaskela *et al.,* 2017; Lwoga, 2012; Ssekakubo *et al.,* 2011; Unwin et al., 2010; Oye *et al.,* 2011; Margaryan, *et al.,* 2011). These hindrances may include high cost of infrastructure, socioeconomic and technological conditions, lack of a systematic approach to teaching and learning, awareness/education and attitudes towards digital technologies, technical and

administrative support, staff development both teaching and support, and lack of expertise in the use of digital technology.

Studies conducted on the effectiveness of digital technology have proved that the use of digital technology in higher education institutions is neither an automatic assurance that students/ leaners will be enthusiastically involved nor a promise that high scores will be achieved because learners, instructors, and the society require skills and active participation (OECD, 2015a, 2015b; Tamin *et al.,* 2011). However, a number of scholars have provided remedies of dealing with these challenges. They have suggested that these challenges may be mitigated by ensuring that there is an improvement in the pedagogical competences of teachers in the use of digital technology through the inclusion and modelling of good digital citizenship others (Choi *et al.,* 2018, Redecker, 2017).

Basing on the above findings, this study therefore advocates for the revamping of the whole HEIs curriculum to ensure it embraces digital technology as well as to encourage the educators and the learners to have a positive proclivity to digital technology and wholesomely embrace it.
Studies conducted in prior research has indicated that there are vast ubiquitous cost effective and efficient methods of implementing digital technology in HEIs. The most effective digital technologies which have produced positive results are the computerized tomography machine or communications that are associated with a video platform. From the literature collected and analysed, one can note that ZOOM and mobile applications are effective and efficient methods that can be used for the distance teaching and learning process in HEIs (Benavides et al., 2020).

Most scholars favored MOODLE as being effective as well as compared to Blackboard. More so MOODLE and Web 2.0 had advantages of being efficient in the development of e-learning. However, these methods have a disadvantage that these web services are not controlled the respective institutions (Zhao, Liao & Sun, 2020).

5.0 Conclusion

Digital technology has had an impact on daily life let alone the teaching and learning environment (Anderson, 2016; Smith & Anderson, 2016; Zickur & Raine, 2014). Teaching and learning activities have been facilitated by such concepts as blended learning in which face-to-face interactions between the instructor and the learners is mixed with online teaching and learning. It is important for HEIs to identify technologies that are ideal for their specific learning needs, find out opportunities that can be presented by different digital technologies, establish the challenges faced when implementing digital technologies in HEIs and embrace the most cost-effective and efficient methods of implementing and using digital technologies.

This research study cannot be complete without attributing the immense contributions of previous research work which brought vast contributions to the body of knowledge beginning with diverse definitions of digital technology and synchronizing these with dimensions of digital technology (Benavides et al., (2020).

6.0 References

Anderson, M. (2016). More Americans using smartphones for getting directions, streaming TV. Washington, D.C.: Pew Research Center Retrieved from http://www.pewresearch.org/fact -tank/2016/01/29/us-smartphone-use/

Aresta, M., Pedro, L., & Santos, C. (2015). Mobile learning and higher education: A theoretical overview. Journal of Mobile Multimedia, 11(1-2), 147-156.

Armstrong & Franklin, T., J. (2008). A review of current and developing international practice in the use of social networking (Web 2.0) in higher education. In: Franklin Consulting.

Balakrishnan, B., & Woods, P. C. (2013). A comparative study on real lab and simulation lab in communication engineering from students' perspectives. European Journal of Engineering Education, 38(2), 159-171. doi:10.1080/03043797.2012.755499

Becker, S. A., Cummins, M., Davis, A., Freeman, A., Glesinger Hall, C., & Ananthanarayanan, V. (2017). NMC Horizon Report: 2017 Higher Education Edition. Retrieved from Austin, Texas.

Beebe, M. A. (2004). Impact of ICT revolution on the African academic landscape. In CODESRIA Conference on Electronic Publishing and Dissemination (pp. 1–2). Dakar. https://www.codesria.org/IMG/pdf/Maria_A_Beebe

Benavides L.M.C., Arias J.A.T., Arango-Serna M. D. A., Bedoya J.W.B., and Burges D., (2020) Digital Transformation in HEIs: A Systematic Literature Review.

Bozkurt, A., Akgün-Özbek, E. & Zawacki-Richter, O. (2017). Trends and Patterns in Massive Open Online Courses: Review and Content Analysis of Research on MOOCs (2008-2015). *International Review of Research in Open and Distributed Learning*, *18*(5), 118–147.

Bresinsky M, Von Reusner F. (2017) GLOBE–Learn and innovate digitization by a virtual collaboration exercise and living lab. In Proceedings of the 6th International Conference, ArtsIT 2017, and Second International Conference, DLI 2017, Heraklion, Crete, Greece, 30–31 October 2017.

Bullen, M., & Morgan, T. (2015). Digital learners in higher education: Implications for teaching, learning & technology. Teaching and learning in digital worlds: Strategies and issues in higher education, 11-19.

Carbonell Carrera, C., & Bermejo Asensio, L. A. (2017). Landscape interpretation with augmented reality and maps to improve spatial orientation skill. Journal of Geography in Higher Education, 41(1), 119-133. doi:10.1080/03098265.2016.1260530

Cuthbertson, L. M., Robb, Y. A., & Blair, S. (2020). Theory and application of research principles and philosophical underpinning for a study utilising interpretative phenomenological analysis. *Radiography*, *26*(2), e94-e102.

Choi, M., Cristol, D., & Gimbert, B. (2018). Teachers as digital citizens: The influence of individual backgrounds, internet use and psychological characteristics on teachers' levels of digital citizenship. Computers & Education, 121, 143–161. https://doi.org/10.1016/j.compedu.2018.03.005

Dubovi, I., Levy, S. T., & Dagan, E. (2017). Now I know how! The learning process of medication administration among nursing students with non-immersive desktop virtual reality simulation. Computers and Education, 113, 16-27. doi:10.1016/j.compedu.2017.05.009

Estriégana-Valdehita, R., Plata, R. B., & Medina-Merodio, J. A. (2017). Educational technology in flipped course design. International Journal of Engineering Education, 33(4), 1199-1212.

Garrison, D. R., & Kanuka, H. (2004). Blended learning: Uncovering its transformative potential in higher education. The internet & higher education, 7(2), 95–105.

Garrison, D. R., & Vaughan, N. D. (2008). Blended learning in higher education: framework, principles, and guidelines business professional collection businesspro collection jossey-bass higher and adult education series. Wiley. ISBN 0787987700

Gaur, A., & Kumar, M. (2018). A systematic approach to conducting review studies: An assessment of content analysis in 25 years of IB research. *Journal of World Business*, *53*(2), 280-289.

Gikas, J., & Grant, M. M. (2013). Mobile computing devices in higher education: Student perspectives on learning with cellphones, smartphones & social media. The Internet & Higher Education, 19, 18–26.

Gough, D., Oliver, S., & Thomas, J. (2012). *An introduction to systematic reviews*. London, England: Sage.

Grab B, Olaru M, Gavril R. (2019) Self-managed as a key to unlocking digital transformation in business management. Qual Success. 20, 280–6.

Han, I., & Shin, W. S. (2016). The use of a mobile learning management system and academic achievement of online students. Computers and Education, 102, 79-89. doi: 10.1016/j.compedu.2016.07.003

Jääskelä, P., Häkkinen, P., & Rasku-Puttonen, H. (2017). Teacher beliefs regarding learning, pedagogy, and the use of technology in higher education. Journal of Research on Technology in Education, 49(3–4), 198–211. https://doi.org/10.1080/15391523.2017.1343691.

Kaware, S. S., & Sain, S. K. (2015). ICT Application in Education: An Overview. International Journal of Multidisciplinary Approach & Studies, 2(1), 25–32.

Kingston, D. G., Eastwood, W. J., Jones, P. I., Johnson, R., Marshall, S., & Hannah, D. M. (2012). Experiences of using mobile technologies and virtual field tours in Physical Geography: Implications for hydrology education. Hydrology and Earth System Sciences, 16(5), 1281-1286. doi:10.5194/hess-16-1281-2012.

Kirkwood, A. (2009). E-learning: You don't always get what you hope for. Technology, Pedagogy and Education, 18(2), 107–121. https://doi.org/10.1080/14759390902992576.

Kirkwood, A., & Price, L. (2005). Learners and learning in the twenty-first century: What do we know about students' attitudes towards and experiences of information and communication technologies that will help us design courses? Studies in Higher Education, 30(3), 257–274. https://doi.org/10.1080/03075070500095689.

Laurillard, D. (2005). E-learning in higher education. In Changing Higher Education (pp. 87–100). Routledge. https://pdfs.semanticscholar.org/bd4b/21917cd3dbd706d2fa9bfd31f8c8d3178753.pdf.

Lovino, F., & Tsitsianis, N. (2020). The Methodology of the Research. In *Changes in European Energy Markets*. Emerald Publishing Limited.

Lwoga, E. (2012). Making learning and Web 2.0 technologies work for higher learning institutions in Africa. CWIS, 29(2), 90–107.

Marcelo, C., & Yot-Domínguez, C. (2018). From chalk to keyboard in higher education classrooms: Changes and coherence when integrating technological knowledge into pedagogical content knowledge. Journal of Further and Higher Education, 1–14. https://doi.org/10.1080/0309877X.2018.1429584

Margaryan, A., Littlejohn, A., & Vojt, G. (2011). Are digital natives a myth or reality? University students' use of digital technologies. Computers & Education, 56(2), 429–440. https://doi.org/10.1016/j.compedu.2010.09.004

Moldavska, A., & Welo, T. (2017). The concept of sustainable manufacturing and its definitions: A content-analysis based literature review. *Journal of Cleaner Production*, *166*, 744-755.

Moore, J. L., Dickson-Deane, C., & Galyen, K. (2011). e-learning, online learning, and distance learning environments: Are they the same? The Internet and Higher Education, 14(2), 129–135.

Nava J. F., (2020) Digital Technology in College Courses and their effects on learning.

Neira, E. A. S., Salinas, J., & Crosetti, B. B. (2017). Emerging Technologies (ETs) in education: A systematic review of the literature published between 2006 and 2016. International Journal of Emerging Technologies in Learning, 12(5), 128-149. doi:10.3991/ijet.v12i05.6939.

Ng'ambi, D., & Bozalek, V. (2015). Massive open online courses (MOOCs): Disrupting teaching and learning practices in higher education. British Journal of Educational Technology, 46(3), 451–454.

Njenga, J. K., & Fourie, L. CH. (2010). The myths about e-learning in higher education. BJET, 41(2), 199–212.

Norman, H., Din, R., Nordin, N., & Ryberg, T. (2013). A review on the use and perceived effects of mobile blogs on learning in higher educational settings. Asian Social Science, 10(1), 209-222. doi:10.5539/ass.v10n1p209.

Norman, H., Din, R., Nordin, N., & Ryberg, T. (2013). A review on the use and perceived effects of mobile blogs on learning in higher educational settings. Asian Social Science, 10(1), 209-222.doi:10.5539/ass.v10n1p209.

OECD (2015a). Schooling redesigned. OECD Publishing. https://doi.org/10.1787/9789264245914-en.

OECD (2015b). Students, computers and learning. OECD Publishing. https://doi.org/10.1787/9789264239555-en.

OECD (2018a). Teaching for the future : Effective classroom practices to transform education. OECD. https://doi.org/10.1787/9789264293243-en

Oye, N., Noorminshah, A., & Rahim, N. A. (2011). Examining the effect of technology acceptance model on ICT usage in Nigerian tertiary institutions. JETCIS, 2(10), 533–545.

Pedro, L., Barbosa, C., & Santos, C. (2018). A critical review of mobile learning integration in formal educational contexts. International Journal of Educational Technology in Higher Education, 15(1), 10.

Pinto M., and Leite C., (2020) Digital Technologies n support of students learning in higher education: Literature review. Digital Education Review Issue No. 20 pp. 343-360.

Porter, W. W., Graham, C. R., Spring, K. A., & Welch, K. R. (2014). Blended learning in higher education: Institutional adoption and implementation. Computers & Education, 75, 185–195.

Rice, M. F. (2003). Information and communication technologies and the global digital divide: Technology transfer, development, and least developing countries. Comparative Technology Transfer and Society, 1(1), 72–88.

Riemer, K.; Uri, G.; Hamann, J.; Gilchriest, B.; Teixeira, M. (2019) Digital disruptive intermediaries. Available online: https://ses.library.usyd.edu.au/bitstream/handle/2123/12761/ADTL_Digital%20Disruptive%20 Itermediaries-final.pdf?sequence=7&isAllowed=y (accessed on 20 August 2021).

Rodrigues LS. Challenges of digital transformation in higher education institutions: A brief discussion. K.S. S, editor. In Proceedings of the 30th Int Bus Inf Manag Assoc Conf-Vis 2020 Sustain Econ Dev Innov Manag Glob Growth, IBIMA. Available online: https://www.scopus.com/inward/record.uri?eid=2s2.085048618825&partnerID=40&md5=65525232d18dbc0ae37a733eb45b100d (Accessed on 20 August 2021).

Rumanyika, J. D., & Galan, R. M. (2015). Challenges for teaching and learning information and communication technology courses in higher learning institutions in Tanzania: A review. Information and Knowledge Management, 5(2), 1–12.

Schindler L.A., Burkholder G.J., Morad O.A., and Marsh C., (2017) Computer-based technology and student engagement: Acritical Review of the Literature.

Siemens, & Tittenberger, P. (2009). Handbook of Emerging Technologies for Learning. In. Retrieved from http://umanitoba.ca/learning_technologies/cetl/HETL.pdf

Singh, V., & Thurman, A. (2019). How many ways can we define online learning? A systematic literature review of definitions of online learning (1988-2018). *American Journal of Distance Education*, *33*(4), 289-306.

Sleeman, J., Lang, C., & Lemon, N. (2016). Social Media Challenges and Affordances for International Students: Bridges, Boundaries, and Hybrid Spaces. Journal of Studies in International Education, 20(5), 391-415. doi:10.1177/1028315316662975.

Smith, A., & Anderson, M. (2016). Online Shopping and E-Commerce. Washington, D.C.: Pew Research Center Retrieved from http://www.pewinternet.org/2016/12/19/online-shopping-and-e commerce/

Ssekakubo, G., Suleman, H., & Marsden, G. (2011). Proceedings of the south african institute of computer scientists and information technologists conference on knowledge, innovation and leadership in a diverse, multidisciplinary environment, (pp. 231–238). Cape Town: ACM. http://pubs.cs.uct.ac.za/archive/00000712/01/p231-ssekakubo.pdf.

Tamim, R. M., Bernard, R. M., Borokhovski, E., Abrami, P. C., & Schmid, R. F. (2011). What forty years of research says about the impact of technology on learning: A second-order meta-analysis

and validation study. Review of Educational Research, 81(1), 4–28. https://doi.org/10.3102/0034654310393361

Tulinayo F.P., Ssentume P., and Najjuma R., (2018) Digital technologies in resource constrained higher institutions of learning: a study on students' acceptance and usability. International Jouranl of Educational Technology in Higher Education.

Unwin, T., Kleessen, B., Hollow, D., Williams, J. B., Oloo, L. M., Alwala, J., . . . Muianga, X. (2010). Digital learning management systems in Africa: myths and realities. Open Learning, 25(1), 5–23.

Vuorikari, R., Punie, Y., Gomez, S. C., Van Den Brande, G., & et al (2016). DigComp 2.0: The Digital Competence Framework for Citizens. Update Phase 1: The Conceptual Reference Model. Technical report, JRC-Seville site.

Wade M. (2019) Digital business transformation a conceptual framework. Glob Cent Digit Bus Transform Available online: http://www.huffingtonpost.com/vala-afshar/accenture-digital-7-digital-business transformation-lessons_b_6622648.html (accessed on 20 August 2021).

Westera, W. (2015). Reframing the role of educational media technologies. Quarterly Review of Distance Education, 16(2), 19–32.

Zhao M., Liao, H.T., Sun, S.P. (2020) An Education literature review on digitization, digitalization, datafication, and digital transformation. In Proceedings of the 6th International Conference on Humanities and Social Science Research (ICHSSR 2020), Hangzhou, China, 10–12 April 2020.

Zickuhr, K., & Raine, L. (2014). E-reading rises as device ownership jumps. Washington, D.C.: Pew Research Center Retrieved from http://www.pewinternet.org/2014/01/16/e-reading-rises-as-device-ownership-jumps/

Lecturers' readiness as a factor in the uptake of teaching with digital technologies in distance learning: A Zambian case study

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Abstract
Despite technological advances in education, Sub-Saharan higher education institutions (HEIs) are reportedly still staggering under the burden of digital exclusion. Furthermore, crises such as the COVID-19 pandemic have a profound impact on digitally excluded students. Due to its flexibility and affordability for students in remote areas, distance education is a popular option for many African tertiary students. While teaching with technology made huge developmental strides in distance education in most developed countries, many HEIs in less developed countries do not yet benefit from the widely heralded 21st century technological developments.
Literature abounds that many sub-Saharan distance learning intuitions still use traditional and outdated distance teaching and learning practices. The pivotal question begs: how do distance higher education lecturers in the group under study perceive the affordances of digital technologies?
A Zambian focus group study was conducted to explore lecturer attitudes and perceptions towards integrating digital technologies into teaching and learning. Using a combined conceptual framework of the Technological Pedagogical Content Knowledge (TPACK) model and the 21st century 6C's model to frame the study, the current ecosystem was explored. Qualitative data were collected during focus group interviews, transcribed and analysed using Clarke's Six Steps of thematic analysis.
The main finding of the study is that lecturers understand the importance of integrating digital technologies demanded by an ever-changing working world. The study identified the areas responsible for the observed lack of preparedness in the case under study. It offers guidelines on integrating affordable technologies, such as mobile technologies gradually and systematically, within the preamble of the challenges faced in terms of digital exclusion. Although the findings of this focus group study cannot be generalised on a broader scale, finding are in line with similar studies, amplifying the critical role of governance and leadership in HEIs to bring about the required change.
Keywords: TPACK, distance learning, learning with technology, lecturer attributes.

1. Introduction

Distance education is a popular and viable option for many African tertiary students. HE must capitalise on the affordances of technology and equip students with the appropriate attributes. Too many HEIs, however, are still perpetuating old teaching and learning practices, that do not answer the skills requirements of Industry 4.0 (Epure & Mihăeș, 2017).

A distance mode of offering tertiary education could potentially be a solution to expose students to the affordances of digital technologies (Mokoena, 2017). Here, evidence abound that global improvement and uptake of digital technology integration are taking off, albeit, with varying levels of success. Many educators and the students in sub-Saharan higher education institutions (HEIs) are still reeling under the weight of digital inequalities and digital exclusion. Mercader and Gairin (2020) add that many barriers exist and share reasons why lecturers refrain from integrating digital technologies for teaching purposes. These barriers may be prevalent on a personal, professional, institutional, and contextual level, with professional barriers rank higher (Mercader & Gairin, 2020, 2).

This paper reports on a study at a distance HEI in Zambia. Lecturer perceptions and experiences are pivotal to the uptake of digital technologies in a student-centred learning approach. The study reports on the case of a HEI in Zambia offering distance programmes was explored. The study was conducted in-depth in a real-life setting, focussing on the uptake of technology in the Faculty of Education. Educator experiences and attitudes are explored in a bounded system.

2. Background

The Higher Education Act of Zambia, (Act No. 4 of 2013), regulates both public and private HEIs. In 2006 Zambia drafted their national ICT Policy, and subsequently drafted an ICT policy for education (Zambian Ministry of Education, 2006). The Education Authority of Zambia was established in 2015 and is responsible for quality assurance and accreditation of all programmes offered by Zambian HE (UNESCO, 2018). The HEI chosen for this study is one of the 60 accredited private institutions of higher learning in Zambia.

Apart from the six public universities accredited by the Ministry of Higher Education, UNESCO (2018) reported that the Education Authority of Zambia has registered sixty private higher education institutions to date. Farrell and Isaacs (2007) allude to the challenges hampering effective integration of digital technologies in teaching in learning. They profess that in both residential universities and distance HEIs digital literacy and fluency, coupled with a lack of ICT infrastructure are some of the factors holding Zambian HEIs back (Farrell & Isaacs, 2007).

3. Distance Education in Africa

Mokoena (2017) states that distance education is a viable option for many on the African continent and could potentially be a solution to expose students to the affordances learning with digital technologies. In many sub-Saharan countries the traditional model for distance teaching and learning depended on the provision of printed study materials such as module guides. These would typically be distributed via correspondence or during contact sessions (World Bank, 2018). Moore, Dickson-Deane and Galye (2011) explain distance education as a mode of delivery providing learning access to geographically distanced students. In the case reported in this study, the HEI offer distance programmes to nearly 3000 students across sub-Saharan countries.

The Harmonisation of African Quality Assurance and Accreditation Initiative (HAQAA) sets out to address the paucity in standards and protocols for integrating technology in distance learning. In 2018 forty (40) African Countries collaborated in the mapping study to establish accreditation guidelines for Africa. These guidelines include standards for open and distance learning (Dakovic, Kelo, & Rannem, 2018). Zambia was part of this initiative.

Distance learning may take place with or without assistive technology. Distance education and learning may include both synchronous and asynchronous as modes of instructional. Distance education may incorporate educational and other technologies designed to support instruction like that offered in face-to-face classes. Figure 1 explains the five stages of progression from offline distance learning to fully online distance learning (ODL).

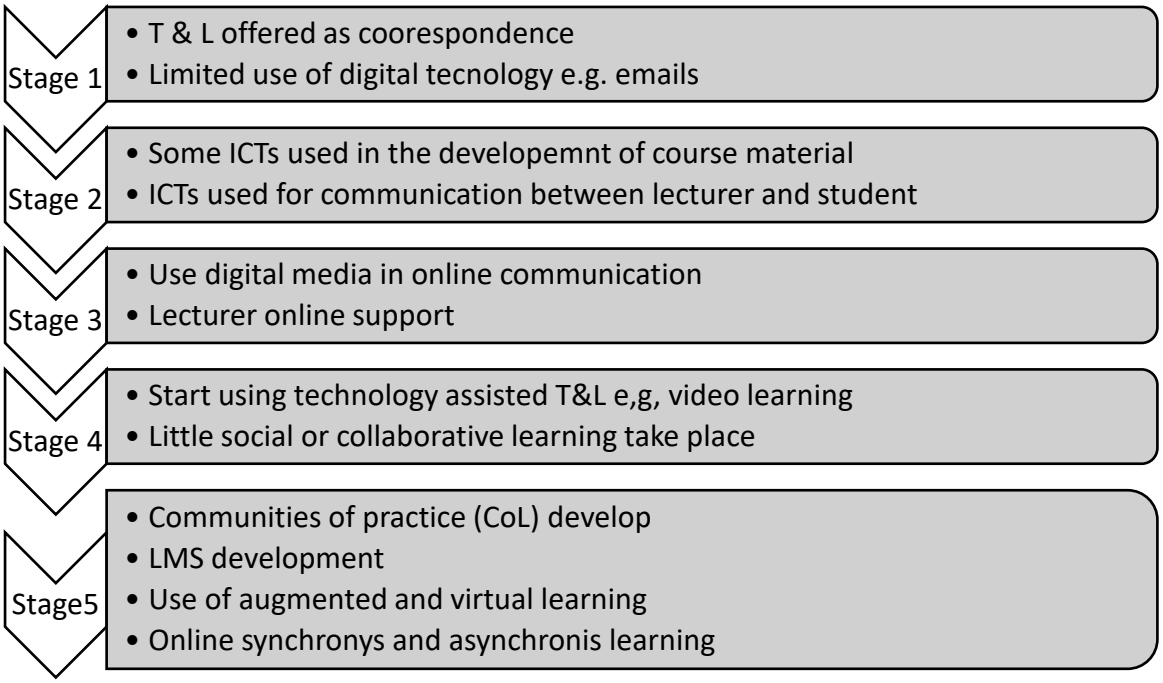

Figure 1. The Five Stages of Development in Distance Education towards Digital Technology Integration (adapted from Pekerti, 2013 & Hedenrych & Prinsloo, 2010**)**

Universities are in a better position now to digitally enhance instruction. There are less differences between distance and face-to-face education as teaching and learning are increasingly becoming a more blended. Kirkwood (2014) laments that distance education providers in developed countries have traditionally integrated and applied new technologies much earlier than developing countries and institutions.

4. Educational Technology and Digital Technologies in Distance Learning

Research (which includes studies by Kirkwood, 2014; Mokoena, 2017) indicates that teaching with technology plays a fundamental role in eLearning, online and distance learning. Kirkwood (2014) argues that advances in education technology and ICTs could potentially blur the line between face-to-face and distance online learning.

Generally, educational technology (ET) can be described as the tools and the processes of integrating learning with technology to promote a more diverse learning environment. There is, however, no consensus on a uniform definition of ET. Lakhana (2014) attempts to clarify and provides an explanation at its simplest form: “ET appears to pertain to the application of mechanical and material tools (especially, computers and computer programs) to problems in education” (Lakhana, 2014:71).

5. The Importance of Lecturer Experience and Attributes in Digital Integration

Moletsi (2014) states that transforming the education system is needed to produce learners and students who are equipped not only with content knowledge but also with ICT knowledge. A positive attitude towards teaching with technology and technological skills is indicative of lecturers’ adoption and use of additional technology in teaching and learning (Oladimeji, Adeyanju, Fakorede, 2017). Kirkwood (2014) argues that the focus should be on human agency on how and when teaching and digital technology can be meaningfully integrated. However, too much emphasis is placed on the technology *per se,* and not the pedagogies to incorporate teaching with technology.

Kunda, Chembe, and Mukupa (2018) allude to the importance of sensitising lecturers on the advantages of using ICTs in their work is an important factor for creating a positive attitude. Over and

above attitude as influencers of ICT adoption, institutional structure, support and policy are indicators of success or failure in the integration of ICTs in teaching and learning.

6. Research Methods and Methodology

In his seminal work, Shulman stated that teacher pedagogical accomplishment was having content knowledge (Shulman, 1986: 7-8), but that the position has changed to include how the teacher is managing, assessing, and organising their teaching and learning. These developments emphasise the lecturer attributes, the skills and the knowledge they need where both content and process are pivotal aspects (Shulman, 1986). Furthermore, he sees pedagogic content knowledge as an overlap of content knowledge and pedagogical knowledge, where teachers need knowledge of strategies that will be most beneficial to learners and students (Shulman, 1986: 9). Shulman takes into consideration the information and prior knowledge that the student brings to the "classroom". Shulman (1986) argues further that knowledge of content and pedagogy must blend to create a flexible learning environment for diverse groups of students.

Mishra and Koehler (2006) allude that Shulman did not specify technology integration *per se*, but that this could be applied to the learning environment, which could include the online or virtual learning environment. As an answer, Mishra and Koehler offered the TPACK framework.
The TPACK model, as explained by Mishra and Koehler (2006), is suitable for studying, gathering data on the application of technologies and understanding among academics of teaching towards 21st century skilling of graduates in a sub-Saharan distance environment. Its strength lies in focusing on all the elements important for teaching with technology, of which lecturer perspectives and experiences are pertinent to this study.

The TPACK framework served to unpack knowledge that participants in this study displayed towards technology integration in their teaching and learning practices. This framework, as depicted in Figure 2, comprises three primary components: content, technology and pedagogy. It is then expanded to include the interactions of pedagogical content knowledge (PCK), technological content knowledge (TCK), technological pedagogical Knowledge (TPK), which combine and form TPACK (Koehler and Mishra, 2009).

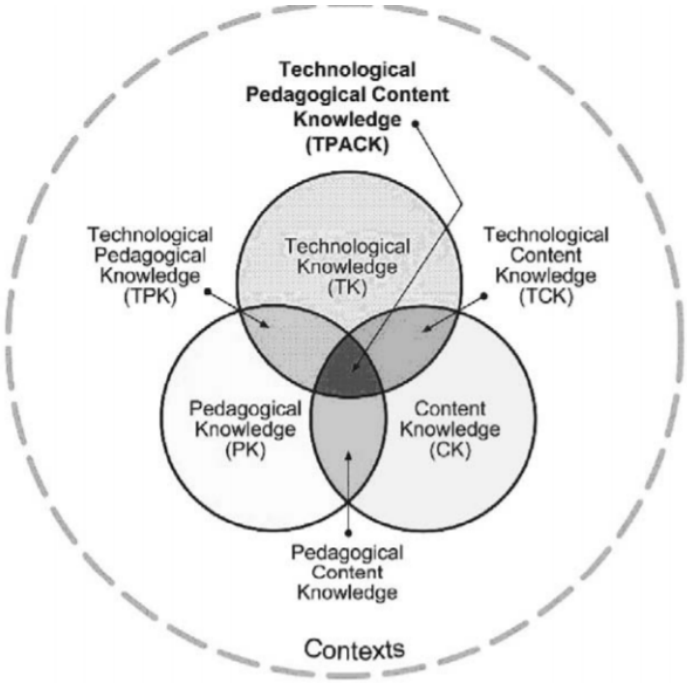

Figure 2. The TPACK framework and its knowledge components (Mishra & Koehler, 2006)

Although several researchers (including Goradia, 2018. Niess, 2011,2015; Valtonen, Sointu, Kukkonen, & Kontkanen, S, 2015) have recently alluded to the need to adapt and expand the TPACK framework to incorporate the foci of 21st learning, no single model has yet been offered. Shafie, Majid, and Ismail (2019) state that an educator's ability to integrate digital technologies is closely related to the TPACK competencies, but they lament that without specific training on how to teach the 21st century skills, educators are likely to be at a lost. Valtonen *et al*. (2015) developed an instrument called TPACK-21 to align TPACK with 21st century teaching and learning skills. For this study the TPACK model, as well as the conceptual framework by Shafie, Majid, and Ismail (2019) were used as frame. This allowed for considering the 6 C's of 21st century learning skills: communication, critical thinking, creativity, citizenship, collaboration and connectivity.

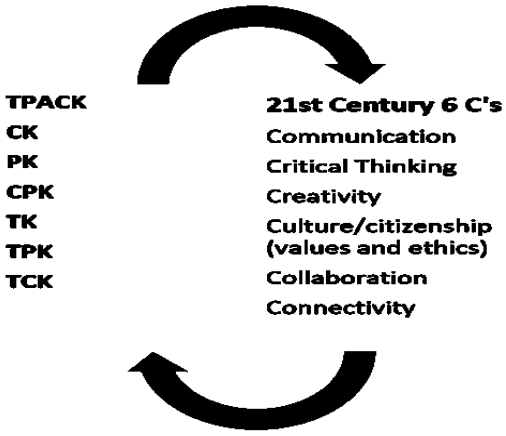

Figure 3. The Combined Conceptual Framework (as adapted from Shafie, Majid, and Ismail, 2019 and Mishra & Koehler, 2006).

Qualitative data were collected during focus group interviews. Focus groups in research studies can be described as a form of group interview in the presence of an interviewer or moderator (Bezuidenhout, Davis, & Du Plooy-Cilliers, 2014). In focus group studies, the interaction within the group is important to get the desired information on a specific research topic and the collective views are more important that the individual's view. In this study, the focus group interview was used as data collection method and was conducted at the HEI in Zambia where all participants, including the researcher, were present. The entire population (*n*=8) attended the session. It allows for observation and discussion of a real-life environment at the HEI in Zambia.

7. Analysis of collected data

The qualitative data collected during the focus group interviews were analysed using thematic reflective analysis. Vaismoradi, Jones, Turunen, and Snelgrove (2016) state that qualitative research, as a group of approaches for the collection and analysis of data, aims to provide an in-depth, socio-contextual and detailed description and interpretation of the research topic.

Thematic analysis is related to phenomenology in that it focuses on the human experience subjectively (Noon, 2018). This approach focuses on the participants' perceptions, opinions, feelings and experiences as the object of study.

Collected data from the transcribed recording, field notes and observation schedule were triangulated. Steps 1-2 of Clarkes six steps (Braun & Clarke, 2006) were done manually. The transcripts were initially analysed within the TPACK themes and the elements of 21st Century learning skills. Then the qualitative data analysis and research tool ATLAS.ti 8 for Windows was used for steps three and

five, and partially for step 6 where initial reports were created and extracted to write the final report. As per step 4 of Clarke's model the interview transcript and researcher observations were uploaded as Word documents.

These themes were used to interpret the data collected from the focus group interview and the observation and field notes.

8. Presentation of Findings

The main finding of this study is that the Faculty of Education was still in the second stage of digital integration at the time of this study. It revealed that the participants, other than CK and PK, generally lacked the TPACK knowledge required to meaningfully incorporate digital technologies.

This study found that it is equally important to have governance structures to support this innovation. The extent of using digital technologies other than the existing student administration technologies is as follows:

- The use of e-mail facilities to communicate to students
- A Website providing access to online information sources such as eBooks, research repositories and journals
- The occasional use of mobile technology for communication to students via phone calls, SMSs and WhatsApp groups

  Despite the positive attitude of lecturers towards integrating digital technologies, the HEI require innovation towards effecting eLearning as explained by Sadeck (2016), where ICT-enhanced teaching and learning take place. The extent of digital and educational technologies currently utilised and integrated with content knowledge (CK) offered for teaching and learning in the faculty is limited, unstructured and dependant on the initiative and skills of individual lecturers.
- Academics displayed some experience, skills, but not apply this in teaching practice in a coordinated and planned manner. The perceptions and understanding of technological knowledge (TK) towards teaching with technology and the use of digital technologies for teaching and learning in a distance environment is limited.
- Academics displayed pedagogical knowledge (PK) in general but lack a deeper understanding and knowledge of 21st century learning skills.

There is a lack of institutional strategy to support the faculty in creating an inducive environment to support teaching and learning with technology.

After the data were analysed four broad themes (see figure 4) impacting lecturer experiences, attributes and perceptions emanated:

1. Governance and compliance observed in the HEI
2. Resources and Infrastructure that impacts on teaching with technology
3. Observed lecturer attributes
4. Student profiles as explained and presented by participants

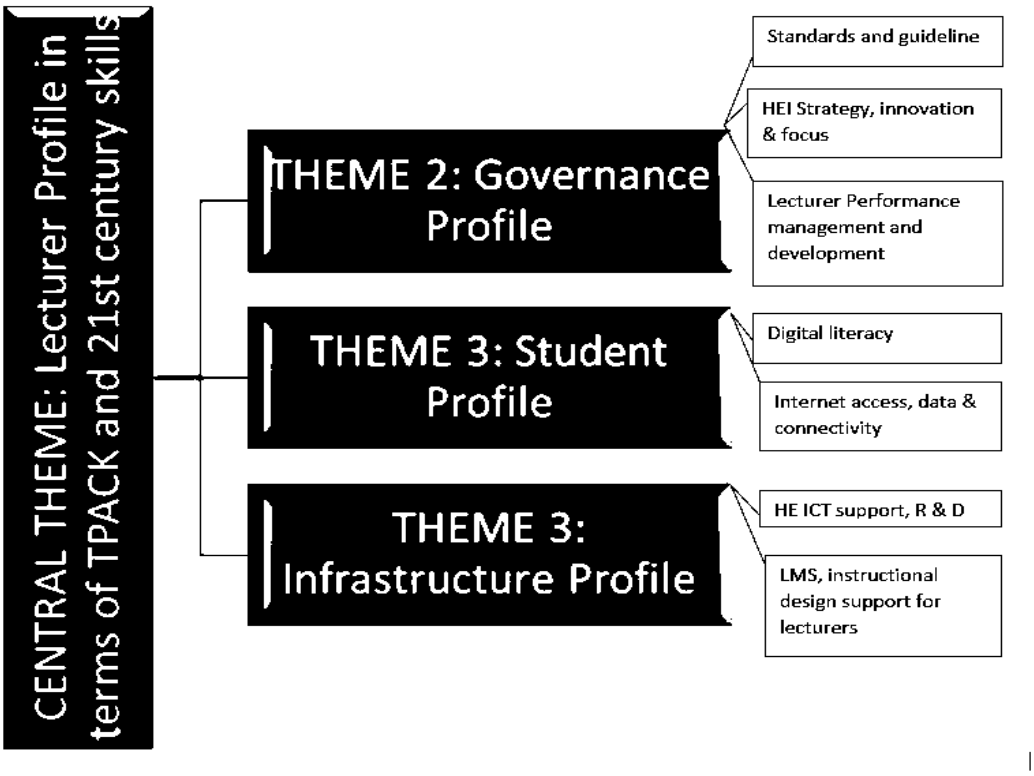

Figure 4. Themes Impacting Lecturer Experience towards the integration of Digital Technologies in Teaching and Learning.

9. Recommendations

Goradia (2018) states that lecturer perspectives and experience are important in effective teaching and learning. It impacts how lecturers transfer 21st century skills. Mercader and Gairin (2020) add that technology inclusion hinges on institutional deficits characterised by the absence of institutional and governance proactiveness, strategies, and models for integrating digital technologies into the classroom. The finding of this study correlate with these reported studies.

The recommendation is that the HEI start with developing a strategy on governance level that will support ODL in its true sense. Ideally such a strategy should include and address the following elements:

- Create a better understanding of the importance the role of quality HEI in Africa
- Build lecturer skills and attributes towards becoming innovative in distance, online pedagogies and instructional design
- Address student preparedness, digital skilling and literacy competency
- Creating an eLearning strategy
- Solutions to address competitivity problems
- Take steps and measures on capitalising on the affordances of mobile learning and video learning, as forms of microlearning in technology assisted teaching and learning
- Become more informed, networked and involved by initiatives driven by AU, UNESCO.

This would need to include and address reskilling of lecturers and a redevelopment of curricula. It is recommended that given the challenges that students experience with connectivity; the mobile

learning option should form a part of the strategy as a viable alternative towards teaching with technology. The HEI could find value in developing and planning the integration of technology in teaching and learning by following the model offered by Kopcha (2008).

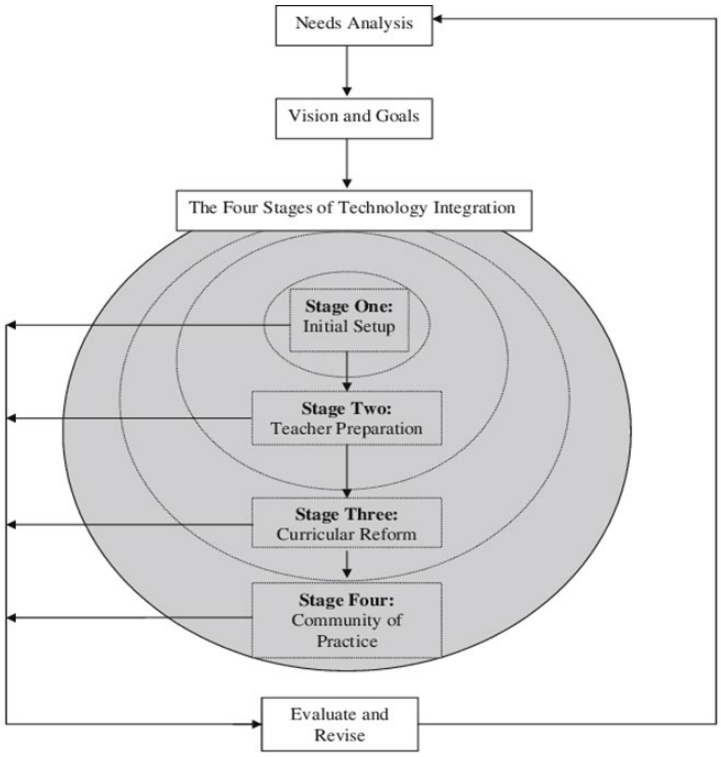

Figure 5. A systems-based approach to technology integration (Kopcha, 2008)

The HEI would need to do a comprehensive needs analysis for integrating digital technologies. The four phases to be followed are: deciding on an initial setup, preparing and training lecturers for this change, adapt curricula and assessments, and creating support through communities of practice.

10. Conclusion

Based on the combined conceptual framework (depicted in figure3), and the themes impacting lecturer preparedness as explained in Figure 4, the findings of this study are that governance and infrastructure challenges are the main stumbling blocks in preparing the participants in this study to capitalise on the affordances of teaching with technology.

In summary, the study concluded that all participants are highly skilled academics in their respective disciplines (PK and CPK). They are critically aware of the technical skills they that they attest to not having (TK and TCK). Although their 21st Century teaching and learning skills, as explained by Shafie, Majid & Ismail (2019), are reportedly underdeveloped, they have a strong ethos and praxis towards student-centredness despite of the digital exclusion dilemmas they are facing. Their dedication, critical thinking, communication, collaboration and often creativity in overcoming their inherent challenges is evident.

At the time of this study, it was evident that ICTs are applied mostly for administrative purposes and not for teaching with technology. The extent of ICT assisted teaching and learning is minimal and is dependent on the initiative of individual lecturers. Even though the HEI refers to itself as an ODL, at present there are no information or evidence on strategies, practice or policies to support this. The

HEI in this study confirms the concerns of researchers that there are African HEI still practicing according to old and outdated practices.

Due to the size and nature of this qualitative focus group study, the findings may not easily be generalised. However, the findings succeed to add to the body of knowledge in terms of prevailing importance of lecturer knowledge of drivers of change and innovation. There is a need to conduct similar research in more HEI in Africa and Zambia. A next research project would be the development of an implementation plan and programme to prepare the HEI for implementing the recommendations.

A further area identified for research is to expand the study to include the HEI governance and management structure, as well as students.

11. References

Bezuidenhout, R.-M., Davis, C., and Du Plooy-Cilliers, F. (2014). *Research Matters*. Claremont: Juta and Company [Pty] Ltd. Retrieved from http://search.ebscohost.com.ezproxy.iielearn.ac.za/login.aspx?direct=true&db=nlebk&AN=746917&site=ehost-live

Braun, V. and Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3, 77–101.

Dakovic, G., Kelo, M. and Ranne, P., (2018) *Mapping of the existing standards and guidelines in quality assurance in African countries and a brief introduction to quality assurance in the European Higher Education Area.* April 2018. Prepared by the HAQAA Initiative Consortium on behalf of the European and African Union Commissions

Dede, C. (2010). Comparing frameworks for 21st century skills. In J. Bellanca & R. Brandt (Eds.), *21st century skills: Rethinking how students learn*. 2010:(51–76).

Dede, C. (2014). The role of digital technologies in deeper learning. Students at the Center: Deeper Learning Research Series. Harvard University: Harvard

Denzen, N.K. (2012). Triangulation 2. 0. *Journal of Mixed Methods Research* 6(2) 80–88 DOI: 10.1177/1558689812437186

Epure, M. and Mihăeș, L. C. (2017). Critical Considerations about the Adoption of Technology-integrated Teaching Methods in Higher Education. *ELearning & Software for Education,* 2, 77–83. https://doi-org.ezproxy.iielearn.ac.za/10.12753/2066-026X-17-097

Farrell, G. and Isaacs, S (2007). Survey of ICT and Education in Africa (Volume 2): 53 Country Reports. Washington, DC: infoDev / World Bank.

Goradia, T. (2018). Role of Educational Technologies Utilizing the TPACK Framework and 21st Century Pedagogies: Academics' Perspectives. *IAFOR Journal of Education,* 6(3), 43–61. Retrieved from http://search.ebscohost.com.ezproxy.iielearn.ac.za/login.aspx?direct=true&db=eue&AN=136371863&site=ehost-live

Hansch, A., Hillers, L., McConachie, K., Newman, C., Schildhauer, T., and Schmidt, P. (2015). Video and online learning: Critical reflections and findings from the field. *SSRN Electronic Journal.* https://doi.org/10.2139/ssrn.2577882

Heydenrych, F.J. and Prinsloo, P. (2010). Revisiting the five generations of distance education: Quo vadis? *Progressio* 32 (1) 2010, 5–26.

Isaacs, S., Roberts, N. and Spencer-Smith, G. (2019). Learning with mobile devices: A comparison of four mobile learning pilots in Africa. *South African Journal of Education*, *39*(3), 1–13. Retrieved from https://doi-org.ezproxy.iielearn.ac.za/10.15700/saje.v39n3a1656

Kirkwood, A. (2014). Teaching and learning with technology in higher education: blended and distance education needs 'joined-up thinking' rather than technological determinism. *Open Learning*, 29(3), 206–221. Retrieved from https://doi-org.ezproxy.iielearn.ac.za/10.1080/02680513.2015.1009884

Koehler, M. J. and Mishra, P. (2009). What is technological pedagogical content knowledge (TPACK)? *Contemporary Issues in Technology and Teacher Education, 9*(1), 60–70.

Koehler, M. J., Shin, T. S., and Mishra, P. (2012). How do we measure TPACK? Let me count the ways. In R. N. Ronau, C. R. Rakes, & M. L. Niess (Eds.), *Educational technology, teacher knowledge, and classroom impact: A research handbook on frameworks and approaches* (16-31). Hershey, PA: IGI Global

Koehler, *M.J.*, *Mishra*, *P.* & *Cain*, *W.* (*2013*). What Is *Technological Pedagogical Content* Knowledge (*TPACK)? Journal* of *Education*, *193* (*3*), *13-19*.

Kopcha, T.J. (2008) A systems-based approach to technology integration using mentoring and communities of practice, *Education Tech Research Dev* (2010) 58:175–190. DOI 10.1007/s11423-008-9095-4

Kunda, D, Chembe, C, and Mukupa, G. (2018). Factors that influence Zambian higher education lecturer's attitude towards integrating ICTs in teaching and research. Journal of Technology and Science Education, [S.l.], 8 (4): 360-384, July 2018. Retrieved from <http://www.jotse.org/index.php/jotse/article/view/338/343>. Date accessed: 07 mar. 2019. Doi: HTTP://dx.doi.org/10.3926/jotse.338.

Lakhana, A. (2014). What is Educational Technology: An Inquiry into the Meaning, Use, and Reciprocity of Technology, *Canadian Journal of Learning and Technology,* Summer 2014, 40(3):1-18.

Mercader, C., Gairín, J. University teachers' perception of barriers to the use of digital technologies: the importance of the academic discipline. *Int J Educ Technol High Educ* **17,** 4 (2020). https://doi.org/10.1186/s41239-020-0182-x

Mishra, P and Koehler, M.J. (2006). *Technological Pedagogical Content Knowledge: A Framework for Teacher Knowledge*, Michigan University: Michigan.

Mokoena, S. (2017). Student Teachers' Experiences of Teaching Practice at Open and Distance Learning Institution in South Africa, *Turkish Online Journal of Distance Education-TOJDE* April 2017, 18 (10).

Moletsi, A.R. (2014) Secondary-school teachers' information communication technology competencies in classroom practices. UNISA: Thesis submitted in accordance with the requirements for the degree of Doctor of Education.

Moore, J.L, Dickson-Deane, C, and Galyen, K (2011) e-Learning, online learning, and distance learning environments: Are they the same? *The Internet and Higher Education*, 14(2): 129-135. Retrieved from: https://doi.org/10.1016/j.iheduc.2010.10.001.

Noon, E. J. (2018). Interpretive Phenomenological Analysis: An Appropriate Methodology for Educational Research? *Journal of Perspectives in Applied Academic Practice,* 6(1), 75–83. Retrieved from http://search.ebscohost.com.ezproxy.iielearn.ac.za/login.aspx?direct=true&db=eue&AN=133659128&site=ehost-live

Oladimeji, O.F. Adeyanju. L.O. and Fakorede S.O.A (2017). Colleges of Education Lecturers Attitude Towards the Use of Information and Communication Technology in Nigeria. *Malaysian Online Journal of Educational Sciences,* 2017 5(4): 1-12.

Shafie, H, Majid, F.A, and Ismail, I.S. (2019) Technological Pedagogical Content Knowledge (TPACK) in Teaching 21st Century Skills in the 21st Century Classroom
Technological Pedagogical Content Knowledge (TPACK) in Teaching 21st Century Skills in the 21st Century Classroom.

Shulman, L.S. (1986). Those Who Understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4-14, Retrieved from http://www.jstor.org/stable/1175860

Valtonen, T., Sointu, E., Kukkonen, J and Kontkanen, S (2015) TPACK updated to measure pre-service teachers' twenty-first century skills, Seminar.net - International journal of media, technology and lifelong learning 11(2): 1-14

World Bank (2018). Technology Offers New Possibilities for Teaching and Learning, Education Focus Area: New Technologies, flyer prepared for the World Bank Annual Meetings. 2018

Exploring the impact of Mobile Instant Messaging on learning: An engineering student perspective

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Abstract
This paper reflects on the drawbacks of mobile instant messaging (MIM) applications (apps) when used for teaching and learning (T&L) in higher education (HE) against the backdrop of the COVID-19 pandemic. In this context, nuanced MIM T&L interventions were developed and deployed by two lecturers in the Faculty of Engineering at a University of Technology (UoT) to overcome challenges. Example of such challenges such as limited or restricted access to devices and data faced by certain students.
Initial research by the authors last year deduced that MIM apps were useful, easily accessible, low-tech, low-cost/low-data usage T&L tools that widened access to education, promoted inclusivity and thereby facilitated student access, retention and success. However, the authors acknowledged some drawbacks. Thus, this study explored student perceptions on the extent to which students were adversely affected as a result of using MIM apps for T&L.
A mixed method research instrument (n=69) was designed in which three research lenses suggested by Fraser (2008) were used to evaluate student perceptions of MIM apps. These lenses were (1) redistribution (of resources), (2) recognition (related to social status) and (3) representation (who can act/say/challenge) in an academic environment. Ethical clearance was sought through institutional channels.
Our results indicate that despite the benefits of using the MIMs app which were reported by previous studies, specific significant barriers, such as misunderstandings and conflicts that arose directly from the use of MIM apps threaten the academic project.
Keywords:
Mobile instant messaging, teaching and learning, ERT, mobile learning, Social Justice, Participatory Parity

1. Introduction

Evolutions in technology have contributed towards the emergence of new and innovative pedagogical approaches in recent years (Kauppi, Muukkonen, Suorsa, and Takala, 2020) and the COVID-19 pandemic, in particular, has propelled transformation in Higher Education (HE) towards remote education. An increased interest has been shown in understanding how universities responded to the pandemic. (Bao, 2020; Greene, 2020; Huang, Liu, Thili, Yang and Wang, 2020; Lim, 2020; QS, 2020); however, fewer studies reflect on the abrupt switch to online teaching, especially mobile learning and the significant impact on students and society.

Against this backdrop, Gronseth and Zhang, (2018) advanced that mobile instant messaging (MIM) apps can be used as part of an inclusive digital learning strategy. They posit that through simple text messages and communication between students and lecturers, the apps can create a closer bond between students and lecturers, which results in better academic achievement. Moreover, various studies reported that MIM apps foster communication and collaboration among peers (Nitza and Roman, 2016), enhance social presence (Tang and Hew, 2017), improve access to resource materials and provide peer support (Timmis, 2012). This study explores the impact of MIM app teaching interventions that were developed by lecturers at a UoT as a tool to teach students, facilitate and

engage in class interactions and transfer content during the national lockdown when face to face teaching was not possible.

2. Literature Review

Citing Fraser (2008), Bozalek (2016: 91) argues that social justice may be equated to participatory parity. She refers to participatory parity as the ability to interact socially on an equal footing with peers. She argues that several social arrangements framed by Fraser's (2008) 3Rs (redistribution, recognition and representation) are required for the inception of participatory parity (or social justice). Significantly, she points out that the three dimensions are entwined and impact each other, however, importantly, none are reducible to the other.

Discussing emerging technologies for teaching and learning, Bozalek (2016: 91) points out that although sophisticated technologies are portrayed as a feasible solution to teach in the resource-rich global north environments, in resources-constrained contexts (such as the UoT where this intervention took place), careful thought and consideration needs to be taken to ensure social justice in the classroom environment. This is foregrounded by several researchers, such as Oyewole, Animasahun and Chapman (2020); Gon and Rawekar (2017) and So (2016) who explored the use of MIM apps to teach. For developing countries such as South Africa (SA), the use of MIM apps represents a practicable solution to overcome challenges of restricted access to devices and limited data as a result of historical socio-economic difficulties. Significantly, research by Patnaik and Swartz (2020) on using MIM apps to teach during the lockdown found there are several positive implications of using MIM apps, such as simplicity, quick and easy access for students to course work, swift feedback, self-motivation and time management. Thus, using the 3Rs as a guide, this study set out to explore the usefulness of a MIM app teaching intervention when used as a tool to teach students, facilitate and engage in class interactions and transfer content during the lockdown, when face to face teaching was not possible.

2.1 Learning in Lockdown

The coronavirus disease (COVID-19) was declared a pandemic by the World Health Organization (WHO) on March 12, 2020 (WHO, 2020). Viner et. al., (2020), reported that in an estimated 107 countries across the globe, educational institutions were closed as a measure to curb the spread of COVID-19.

Van Aard and Sibanda (2021) reported that in SA, some students were forced to return home during the national lockdown. They advanced that 'home' for some students meant a remote place without any technological infrastructure, where the nearest place with internet reception is a library a few kilometres away. For other students, 'home' is a low income, densely populated township on metropolitan outskirts, where the environment is not conducive to studying. Moreover, in several homes where resources were available, they needed to be shared with other members of the family. Van Aard and Sibanda (2021) depict this period as one characterised by crippling fear, anxiety and prejudice, as a result of the pandemic.

Thus, the South African Minister of Higher Education's (HE) announcement "*leave no student behind*" on 30 April 2020 (Parliamentary Monitoring Group 2020) triggered the exploration of various forms of technology by HE lecturers in an attempt to continue teaching. This included considering low tech remote teaching aids such as MIM apps.

2.2 Mobile Instant Messaging Applications and Emergency Remote Teaching

Mobile instant messaging enables smartphone and/or mobile phone users to engage in instant messaging and provides a platform for users to socially engage with one another on these devices (Ogara, Koh, Prybutok; 2014). Silver et. al., (2019) purport that apps on smartphone and mobile

devices have evolved from mediocre to sophisticated communication tools, with the ability to aid remote learning. They add the use of mobile devices have increased worldwide and there is no question that a large percentage of students at HE institutions in SA own at least one such device. Significantly, smartphones and mobile devices can be used to access internet-based educational platforms via WiFi connectivity on campus, at work and at home.

An international study on adult learners at higher education institutions by Kukulska-Hulme et. al., (2011) revealed smartphones serve as communication, business, and learning tools across several environments, including academic, social, entertainment and business. Moreover, numerous research studies have been published to support the use of messaging systems in the delivery of educational activities. Since these MIM apps are so versatile, they can be used for both teaching and learning support and communication and administrative support (So,2016).

Online learning became the preferred method of teaching and learning with the announcement of the global crises in 2020 for obvious reasons. According to Clark and Mayer (2016), online learning refers to teachings provided on digital devices primarily to aid learning. Although not entirely novel, online learning platforms received heightened attention and as a result of the pandemic, and learning from anywhere without having to wrestle through traffic, or depend on public transport, to name a few, became our new reality. Online learning allows for students to stay informed and keep abreast with the set course material or planned lessons, despite being in a remote location. Online or remote learning and teaching is becoming more and more notable as a method of delivery in spite of the infrastructure challenges most developing countries are facing.

Emergency Remote Teaching (ERT) is a short-term solution for instructional or course delivery to a 'stand-in' delivery method as a result of a crisis (Hodges, Moore, Lockee, Trust and Bond 2020). Emergency remote teaching comprises the complete use of remote teaching solutions for the delivery of course material that would have been taught via face-to-face (contact) or a hybrid (blended) instructional method. The aim of ERT is not to replace an existing educational delivery system, but rather to provide temporary access to lessons and teaching support in a faster, more accessible manner during this state of emergency. This very fact distinguishes emergency remote learning from online learning. Hodges, *et al* (2020), reminds us of school and university closures in other parts of the world as a result of war or times of crisis and reaffirms the use of alternate modes of delivery that are more practical during these times. Some of these include involving radio stations, blended learning and then mobile learning too.

The foregoing discussion draws attention to the value that real-time social media tools such as MIM apps are able to contribute during times of crisis, including the COVID-19 pandemic. The ease of use of MIM apps is an attribute that has expanded its popularity across the educational sector, in and outside the classroom. To contemplate the MIM app teaching intervention the authors adopted a framework by Fraser (2008). Fraser proposed three dimensions that may be used when researching a community of learners. The dimensions are (1) redistribution, (2) recognition and (3) representation, which is referred to as the 3Rs.

Discussing the first dimension, Fraser (2008) suggests that economic structures may impede some members of a community from fully participating. She explains, when members of a community do not have resources to interact as peers, they suffer from distributive injustice or maldistribution. In this instance, 'redistribution' is the corrective action to be taken. In the context of this study, not all members of the community had equal access to adequate devices and/or data to partake in the class. Fraser (2008) deliberates on the second dimension, arguing that when institutionalised hierarchies of cultural value prevent members of a community from interacting in terms of parity, the hierarchies of

cultural value deny members of a particular community a prerequisite standing in the community. As a result, the alienated members suffer from status inequality or misrecognition.

Finally, with reference to the third dimension, Fraser (2008) elucidates that when decision rules inhibit members of a community from fully participating as full partners in social interaction it denies them an equal voice in community discussions and democratic decision-making, Thus, these community members suffer from political injustice or misrepresentation. In our context, this entailed recognising who can act, say or challenge in our academic environment. This was particularly significant at the commencement of lockdown when acknowledging the student voice became critical. During this time, from March to November 2020, several authors (Gachago and Cupido 2020, Agherdien 2020 and Rowe 2020) argued that the only way to sustainably continue the academic programme was to consult with students during planning, to do what is best and realistic for all. By doing this, 'representation' is ensured.

3. The Methodological Approach

In response to the findings of the research by Patnaik and Swartz (2020), this mixed method study was designed by two lecturers from different departments in the Faculty of Engineering at a UoT and commenced in August 2020. The result of the previous study that MIM apps serve a utilitarian function in terms of pedagogy and classroom engagement and are extremely easy to use, making learning highly accessible stimulated this research. The two MIM apps that were used were Telegram and WhatsApp. Despite these advantages, the authors reported that MIM technologies can also have a pedagogical and social impact on learning presence and learning, thus the three social justice dimensions proposed by Fraser (2008) became pivotal in the design of this study.

All the lessons which were part of the courses presented by the two lecturers in semester two (August to November 2020) were delivered via MIM apps. Open-source online software was used to compress course content that was shared on a MIM app to ensure that the least amount of data would be used by the students who received these learning materials. The aim was to develop low data usage resources (between 0.1MB and 8MB) that could be communicated on a low-tech platform which could be part of a multimodal teaching strategy. Informal (formative) assessments took place on the MIM apps; however, the delivery of formal assessments was facilitated on the university's learner management system.

A questionnaire was constructed based on our research aim and a follow up to our pilot study conducted last year and presented at a conference (Patnaik and Swartz, 2020). A research instrument (n=69) which consisted of 19 Likert scale questions and five open-ended questions to elicit students' general perceptions of MIM apps was designed. Descriptive statistical analysis was performed on the data collected by the Likert scale questions and qualitative data analysis (thematic analysis) was performed on the responses to the open-ended questions. Three research lenses were used during data analysis to evaluate student perceptions of MIM apps on concepts derived from Fraser's (2008) 3Rs (who can act/say/challenge) in an academic environment.

A convenience sample was attempted to promote external validity of results; however, of 145 potential research participants, only 69 students completed the questionnaire resulting in a 48% (n=145) response rate. Alpha Cronbach's coefficient was used to ensure the reliability of the Likert scale data collected by the questionnaires. Ethical clearance was sought through institutional channels.

4. Finding and Discussion

The results of the data analysis, as well as a discussion of the findings, are presented below in the order in which they are analysed: first, results of redistribution, then recognition and representation, and finally a discussion of the results.

4.1 Findings on Redistribution

The majority of the participants (62%) felt that, the learning materials were easy to access on the MIM apps. However, notably, only 51% of the participants felt that it was easier to learn weekly lesson content using Telegram than if they attended weekly face-to-face lessons, while 40% of the participants felt it was easier to learn weekly lesson content using WhatsApp than if they attended weekly face-to-face lessons. Only 38% of the research participants felt it was easier to learn weekly content than if they attended weekly webinars (online class meetings) using Telegram and 34% felt that way about WhatsApp. Furthermore, in response to open-ended questions, research participants in this study highlighted some noteworthy disadvantages of using MIM apps, such as "*... it's easier to get lost in a thread of many messages and perhaps miss some important details. A weekly webinar was better in that u* [sic] *had to attend online and interact and still have the recording available*" and "*WhatsApp had too many distractions as it is a social media platform mainly to chat with friends and the updating of statuses was also a distraction."*

Using Fraser's definition of redistribution, it was understood to be "overcoming economic structures may impede some members of a community from fully participating". From the analysis of data, it was surmised that although MIM apps themselves make it easier for students to participate in general in class. This is confirmed with responses such as "*...uses less data, lessons are available in your own time at all times for you to listen to and access"*, "*Easy to access anywhere, get to see other students' questions which can also assist you"* and "*You can access it anytime anywhere, it's convenient. I sat doing my work during hospital visits of my now late grandpa. It helped a lot".* However, a statistically significant proportion of the research participants felt it hindered their learning, despite facilitating redistribution. It was deduced from this that MIM apps as an emergency remote teaching tool added tremendous value in terms of redistribution; however, it is not sustainable as a primary teaching tool over the long term. It was also noted that despite the MIM app intervention being valued by students, in certain instances, there were extenuating factors outside of the control of the UoT or course facilitators that inhibited redistribution efforts. This is illustrated by some of the responses of some research participants to open-ended questions such as *"High chances of being distracted; poor network connectivity; some documents may get lost because of phones that don't have space*", "*If your phone break* [sic]*, you're unable to attend lessons. There's a possibility that you might lose all information, a cell phone is unpredictable"* and "*So many messages at once which were very overwhelming for me".*

4.2 Findings on Recognition and Representation

During data analysis of the questionnaire, overlapping areas between Fraser's (2008) second and third dimensions were observed. From our point of view, 'recognition' is understood to be, an action that is taken to prevent part-time students from feeling unnecessarily vulnerable or discriminated against due to their situations. Simultaneously, 'representation' is understood to be, adopting measures to promote participating as full partners in social interaction and giving them an equal voice in community discussions and democratic decision-making. Analysing the data, it was noted, fostering 'recognition' goes hand in hand with promoting representation. Foregrounded by this, only 47% of the research participants reported it was easier for them to engage with the lecturer with Telegram than in face-to-face classes and only 23% of the research participants felt it was easier for them to engage with the lecturer on WhatsApp than in face-to-face classes. Notably, 57% of our research participants reported that it was easier for them to engage with the lecturer on Telegram than in a webinar and 43% reported that it was easier for them to engage with the lecturer on WhatsApp than in a webinar. In terms of student-to-student (peer) engagement, significantly, only 49% and 43% of

the research participants reported that it was easier for them to engage with other students on Telegram and WhatsApp respectively, than in face-to-face class. Yet 62% and 54% of research participants perceived it was easier to engage with other students on Telegram and WhatsApp respectively, than in webinars. It is believed that these findings are particularly significant since, especially during the lockdown, acknowledging the student voice became critical for the development of sustainable teaching solutions to complete the academic programme.

Related to Fraser's (2008) second dimension on 'recognition' which is concerned with institutionalised hierarchies of cultural value that prevent members of a community from interacting in terms of parity, the response of one research participant to an open-ended question highlighted a particular challenge that some students faced which was not having data. Students were invited to apply for mobile internet data in June 2020 (before this study took place), however, when this study took place six months later, some students were yet to receive their mobile internet data. In this sense, it was deduced that using a MIM app was beneficial to students since very little mobile internet data was required when using Telegram.

Moreover, other responses to open-ended questions showcased student appreciation for the flexibility afforded by MIM apps due to the self-paced user design of the teaching interventions, the feature of having quick and easy access to re-visitable class notes, and recordings, independent of the institution's eLearning platform was another significant advantage. Two research participants highlighted the challenges associated with being reliant on the UoT's ICT service department to resolve problems, such as server downtime and technical issues, which they felt was a common occurrence at the UoT. Being plagued with technical problems, such as server downtime, has an impact on study time. Time management is a critical concern for our students, who struggled to juggle different priorities related to academic life, work and family during the lockdown. Therefore, it was concluded that the use of MIM apps was beneficial for our students.

Aside from these advantages, responses of some research participants to open-ended questions drew our attention to several shortfalls of using MIM apps, which influenced the participants' perception of feeling recognised and represented in the class, such as "*Honestly working in WhatsApp and trying to do group work on WhatsApp or online is the most difficult thing ever, 'cause there's a lot of misunderstandings that end up happening and sometimes messages end up being misread which then ends up making a conflict, whereas face to face it's easier to express yourself without being misunderstood"* From this, it was surmised that if our students and their needs are not duly 'recognised', it would be challenging for them to interact and participate and therefore be appropriately 'represented' in the classroom environment. It was deduced that 'recognition' entails more than mere acknowledgement of unique characteristics and requirements, but also the action associated with the prevention of misrecognition, such as soliciting their requirements before planning a teaching intervention. The preceding findings raised further questions about the extent of social justice in our practice.

4.3 Discussion

The study which stimulated this research revealed that MIM apps are an especially valuable tool for ERT during times of crisis such as the lockdown during the COVID-19 pandemic. This follow-up study has demonstrated that while a MIM app is a powerful pedagogical tool, it is not a silver bullet, and several contributing factors influence a students' ability to learn when it is used as a tool. From the above-mentioned findings, it was deduced that although MIM apps can effectively be used to deliver curriculum content and engage with students in a low-tech, low-cost/low-data usage manner and consequently widen access to education and promote inclusivity, unfortunately, there are also unavoidable negative consequences associated with the use of MIM apps that has an impact on T&L. Equally significantly, our findings also place a spotlight on social justice in the classroom environment

and the impact of technology (such as MIM apps) on social justice. For us, Fraser's (2008) conception of social justice served as a good point of departure, and a useful lens to examine to understand our practices - how technologies, such as MIM apps, can be used as a tool to achieve participatory parity, which in itself, is not the end. Participatory parity in our context was providing our students with an inclusive and enabling learning experience, during a very disruptive and apprehensive time in the world's history. Based on the findings, the authors were unable to conclude that the use of MIM apps contributed to creating a socially just learning environment for our students.

5. Validity, Reliability and Limitations

Cronbach's alpha coefficient was used to ensure internal validity and reliability of the Likert scale survey questions. The Alpha Cronbach's results for all sections of the online survey instrument of this study was above 0.7, thus the instrument was considered to be internally valid and reliable. A limitation of this study was that data was collected from students in one faculty at one UoT, thus these findings cannot be generalised to all situations at different universities.

6. Conclusion and Implications

This study has expanded the view of MIM apps from a student perspective and concludes that, although the MIM apps are a useful tool for ERT, the manner in which they are used for curriculum delivery must be carefully and deliberately constructed to ensure participatory parity in the classroom environment. Despite the benefits of MIM apps that were reported in previous studies, certain significant barriers continue to threaten the success of the academic project, such as misunderstandings and conflicts that arise directly from the use of MIM apps. Message bombardment and privacy were also significant concerns. Ultimately, it was concluded that MIM apps are best suited for use as supplementary tools in a classroom environment, to support the learner management system, and should not be the primary vehicle for curriculum delivery. Notably, our study has only reported on the student perspective of using MIM apps through Fraser's (2008) dimensions of social justice. Therefore, this study recommends further studies to determine the lecturer perspective.

7. References

Agherdien, N. 2020. COVID-19: Towards actions during uncertainty (online). Available: http://heltasa.org.za/covid-19-towards-action-during-uncertainty/ [Accessed 14 April 2020].

Bao, W. 2020. COVID-19 and online teaching in higher education: A case study of Peking University. Human behaviour and emerging technologies, 2(2), pp. 113 - 115.

Bozalek, V. 2016. Participatory Parity and Emerging Technologies (pg 89 - 109) in Walker, M. and Wilson-Strydom, M. (eds) Socially just pedagogies, capability and quality in Higher Education: A Global Perspective. Palgrave MacMillan: London.

Clark, R. C. and Mayer, R. E. 2016. e-learning and the science of instruction (Ruth Colvin Clark & R. E. Mayer, Eds.; 4th ed.). John Wiley & Sons.

Fraser, N. 2008. Abnormal justice (online). Available: http://www.fehe.org/uploads/media/Fraser_Abnormal_Justice_essay.pdf [Accessed 12 June 2020].

Gachago, D. and Cupido, X. 2020. Designing learning in unsettling times (online). Available: http://heltasa.org.za/designing-learning-in-unsettling-times/ [Accessed 27 March 2020].

Gon, S. and Rawekar, A. 2017. Effectivity of e-Learning through WhatsApp as a teaching learning tool. MVP Journal of Medical Sciences. 4(1) 19-25 https://doi.org/10.18311/mvpjms.v4i1.8454.

Greene, J. 2020. How (not) to evaluate teaching during a pandemic? The chronicle of higher education. [online] Available at: <https://www.chronicle.com/article/How-Not-To-Evaluate-Teaching/248434> [Accessed 31st August 2020].

Gronseth, S. and Zhang, H. 2018. Advancing social presence, community, and cognition through online discussions. In M. Marmon (Ed), Enhancing social presence in online learning environments (pp. 117 - 140). Hershey: IGI Global.

Hodges, C., Moore, S., Lockee, B., Trust, T., and Bond, A. 2020. The Difference between Emergency Remote Teaching and Online Learning. EDUCAUSE Review.

Huang, R. H., Liu, D. J., Thili, A., Yang, J, F., Wang, H. H., et al., 2020. Handbook on facilitating flexible learning during educational disruption: The Chinese experience in maintaining undisrupted learning in COVID-19 outbreak. Beijing: Smart learning institute of Beijing Normal University.

Kauppi, S., Muukkonen, H., Suorsa, T., and Takala, M. 2020. I still miss human contact, but this is more flexible - Paradoxes in virtual learning interaction and multidisciplinary collaboration. British journal of educational technology, 0(0), pp. 1 - 16.

Kukulska-Hulme, A., Pettit, J., Bradley, L., Carvalho, A., Herrington, A., Kennedy, D., and Walker, A. 2011. Mature students using mobile devices in life and learning. International Journal of Mobile and Blended Learning. 3(1), 18-52.

Lim, M. 2020. Educating despite the COVID-19 outbreak: lessons from Singapore. [online] Times Higher Education. Available at: <https://www.timeshighereducation.com/blog/educating-despite-covid-19-outbreak-lessons-singapore#survey-answer> [Accessed 30th August 2020].

Nitza, D. and Roman, Y. 2016. WhatsApp messaging achievements and success in academia. International journal of higher education, 5(4), 255 - 261.

Ogara, S., Koh, C., and Prybutok, V. 2014. Investigating factors affecting social presence and user satisfaction with mobile instant messaging. Computers in Human Behaviour, 36 (2014), 453-459.

Oyewole, B., Animasahun, V., and Chapman, H. 2020. A survey on the effectiveness of WhatsApp for teaching doctors preparing for a licensing exam. PLoS One. 15(4) e0231148. doi:10.1371/journal.pone.0231148. PMID: 32240259; PMCID: PMC7117696.

Parliamentary Monitoring Group. 2020. COVID-19 Response: University & TVET plans for 2020 academic year; DSI work on COVID-19; with Minister (online). Available: https://pmg.org.za/committee-meeting/30102/ [Accessed 31 August 2020].

Patnaik, S. and Swartz, B. 2020. Mobile Instant Messaging Applications – Online teaching during COVID-19. digiTAL2020 International Conference on teaching, assessment and learning in the digital age. Virtual conference from 3 – 4 December 2020.

QS, 2020. The impact of the coronavirus on global higher education. [pdf] London: QS, Available at: <https://www.qs.com/portfolio-items/the-impact-of-the-coronavirus-on-global-higher-education/> [Accessed 30th August 2020].

Rowe, M. 2020. Universal principles of learning task design. Crisis edition. (online) Available: http://heltasa.org.za/universal-principles-of-learning-task-design-crisis-edition/ [Accessed 17 April 2020].

Silver, L., Smith, A., Johnson, C., Jiang, J., Anderson, M., and Rainie. L. 2019. Use of smartphones and social media is common across most emerging economies. Available at: https://www.pewresearch.org/internet/2019/03/07/use-of-smartphones-and-social-media-is-common-across-most-emerging-economies/ [Accessed 6 August 2021]

So, S. 2016. Mobile instant messaging support for teaching and learning in higher education. The Internet and Higher Education, 31, 32–42. https://doi.org/10.1016/j.iheduc.2016.06.001

Tang, Y. and Hew, K. F. 2017. Is mobile instant messaging (MIM) useful in education? Examining its technological, pedagogical, and social affordances. Educational Research Review, 21, 85 - 104.

Timmis, S. 2012. Constant companions: Instant messaging conversations as sustainable supportive study structures amongst undergraduate peers. Computers and education, 59(1), 3 - 18.

Van Aard, P. and Sibanda, B. 2021. During lockdown, South African students wrote a book about 'a world gone mad'. The conversation (Online). Available at: https://theconversation.com/during-lockdown-south-african-students-wrote-a-book-about-a-world-gone-mad-161502 [Accessed 10 August 2021]

Viner, R., Russell, S., Croker, H., Packer, J., Ward, J., Stansfield, C., and Booy, R. 2020. School closure and management practices during coronavirus outbreaks including COVID-19: A rapid systematic review. Review, 4, 397–404.

WHO. 2020. World Health Organization. Retrieved from https://www.who.int/southeastasia/outbreaks-and-emergencies/novel-coronavirus-2019.

Are e-Assessments Testing Subject-Specific Learning Outcomes, or Digital Proficiency?

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Abstract
Assessments in Higher Education are increasingly digitised and students are required to use computer devices to display their attainment of learning outcomes. However, digital technologies in the assessment process could lead to construct-irrelevant variance. It is plausible that assessment methods may be testing abilities other than intended learning outcomes resulting in unfair assessment practices. The study used world count in summative essay-type e-assessments as a proxy for keyboard fluency to investigate the relationship between the length of answers and grade awarded for assessments. A systematic approach using analysis of variance correlation testing, and regression analysis indicated a weak positive relationship between the word count and grades. The study demonstrates that shorter answers, possibly due to lower keyboard fluency, should not significantly disadvantage a student's ability to perform during e-assessments. Although students are not necessarily unfairly disadvantaged by e-assessments, not all students operate in a uniform setting when completing e-assessments. Further investigation is suggested to explore the relationship between academic performance and students' access to digital resources and digital proficiency.
Keywords: Assessment, e-assessment, digital proficiency, education technology, fairness in assessment, keyboard fluency.

1. Introduction

Technology plays a crucial role in transforming the modern working environment where students are placed and the educational institutions and processes where students' learning is facilitated. Higher education institutions (HEI) are exploring new technology enhanced learning methods, changing how learning activities, like assessments, are performed. Assessment forms an integral part of learning and quality assurance of learning, as it measures whether a particular learning process is achieving the stated learning outcomes (Crisp et al., 2016).

Given the omnipresence of technology in education, the focus has shifted from how it is used for learning, to how it can be used to advance student achievements. In order for technology to be effective, educators must integrate technology into programs to ensure it aligns with learning outcomes and not skew quality control towards measuring digital proficiency, rather than subject matter expertise (Pennington, 2020). It is essential to ensure that the correct competencies are still assessed when assessments are digitised (Shalatska et al., 2020).

A student's digital capabilities, particularly keyboard fluency, could play a part in their efficiency in completing the technology intrinsic assessments. It is plausible that students with specific digital competencies, such as typing proficiency, could unintentionally be advantaged despite the competencies tested being subject-specific. For example, the ability to type quickly during an e-assessment may enable students to provide longer answers, which could earn better grades (Hillier, 2014). Although most learners indicated that online exams are efficient, usable and reliable, some perceived a level of insufficiency related to exam duration (Ilgaz & Afacan Adanır, 2020) that could be related to keyboard fluency. The majority of participants in a study from Ali and Dmour (2021) indicated that their keyboard fluency is a barrier during online evaluations.

This study investigates the relationship between the length of an essay answer and the grade awarded for the answer. The answer length (word count) serves as a proxy for digital competencies since typing speed represents proficiency associated with higher levels of digital ability. Although the selection of answer length as a proxy to digital proficiency is not perfect, there is some academic support to indicate a relationship between students technical proficiency and ability to perform in e-assessments (Bennett et al., 2020; Ndibalema, 2021; Sharma et al., 2021).

2. Literature review

2.1 Learning and Assessment

How students learn has changed substantially due to the rapid advancement in technology (Pennington, 2020). Research on tertiary teaching and learning is reconsidering the position, role, and significance of assessment in education. As a result, there is a shift of emphasis towards assessment *for* learning, rather than assessment *of* learning (Mimirinis, 2019).

Learning outcomes review what is formally assessed and certified (Andrade et al., 2020). When used correctly, learning outcomes moves the focus away from input (like learning materials) and process (facilitated class sessions) to what the student actually learned. When developing learning outcomes, it is essential to consider the kind of skills and knowledge involved, the level of understanding that a student requires to achieve, and how the learning will be demonstrated through different types of assessment (Amer, 2020). Determining students' skills, knowledge, and abilities occurs through the evaluation of learning outcomes (Ndibalema, 2021).

Assessment forms an integral part of any educational system, and the process of evaluation should align with curricular objectives and learning outcomes (Alsadoon, 2017). Whether an assessment is designed for traditional classroom or online use, assessment principles remain the same. Assessment procedures and policies should reflect academic integrity and quality through a consistent, reliable, appropriate and systematic approach. The criteria for effective assessment include validity and reliability, fairness, credibility, transparency and accountability, social justice and equality, and sensitivity to language (Pennington, 2020). Any deviation from these criteria introduces unfairness in the assessment.

Since assessment defines how, and what a student learns, the assessment method is critical to foster a constructive learning practice (Ndibalema, 2021). Assessment strategies should enable students to demonstrate their skills and improve their learning activities (Ali & Dmour, 2021). Summative assessment denotes the appraisal of learning outcomes and usually takes the form of a test or examination at the end of a specified time interval to assess students' attainment of learning outcomes (Fluck & Hillier, 2016). Summative assessments focus on the application of knowledge to display problem-solving and critical thinking skills.

2.2 Technology and Assessment

Many HEIs are becoming more flexible in how, when and where individuals learn. Part of this flexibility includes adopting e-assessment to develop accurate and faster methods to assess students, rather than traditional measures (Alruwais et al., 2018). Online assessments, also known as e-assessments, are defined as the use of information technology in various forms of assessment (Mimirinis, 2019). Although the assessment methods can be different in online and face-to-face environments, the principles of assessment are similar (Alsadoon, 2017).

E-assessments holds multiple advantages (Ali & Dmour, 2021; Fluck et al., 2017; Ndibalema, 2021). Flexibility and location independence are two significant benefits since a test is available on-demand, can be taken at any time, and students continue to learn from any location (Alruwais et al., 2018).

Conversely, e-assessments also have shortcomings (Sayed & Baker, 2014), often leading to a fear of online assessments (Ndibalema, 2021). Students who view themselves as having poor IT skills may believe that their lack of skills put them at a disadvantage when doing online assessments (Ilgaz & Afacan Adanır, 2020).

Assessment instrument fluency has been proven to be a critical factor in the perception of online assessments, particularly for new content and poor performing candidates (Alsadoon, 2017). As a rule, high accomplishing candidates will adjust quickly to any new method of assessment. However, that is not the case for all students, leading to potential unfairness in evaluation. Only once all students are fully acquainted with the technology used for assessments does familiarity become less of an influencing factor (Alsadoon, 2017). As a result, students' concerns in online assessment perception studies often include technological incompetence (Sharma et al., 2021).

Student performance at the higher education level is affected by various factors. Researchers frequently explore variables that predict student results to improve instructional decision-making. Factors include time taken to complete the assessment, assessment location, and perception of assessment difficulty (Hammonds & Mariano, 2015). Concerns have been raised whether e-assessment compromises the validity of the assessment process by allowing for measurement of unintended features (e.g. familiarity with, or access to technology). New technologies in the assessment process could lead to construct-irrelevant variance (Mimirinis, 2019) where non-subject specific competencies are indirectly tested.

2.3 Digital Proficiency and Fair Assessment

There is limited empirical evidence to support the argument that longer assessment answers result in better student grades. Most of the work has been done comparing handwritten essays with typed essays to determine the difference in length, accuracy and performance. Fluck and Hiller (2016) showed that computer-using students write more words in a fixed time than those using pen and paper. Students that typed, in general, scored slightly better than handwriters, lending support to the more words, higher scores proposition. However, they did not test for other moderating factors like legibility introduced in typed assessments. Interestingly higher handwritten word count generally led to better marks, but more typed words only slightly increased marks (Fluck & Hillier, 2016).

A comprehensive study into the complex construct of digital proficiency and the answer creation process from Bennet et al. (2020) dealt, amongst other things, with the complexity of answer length and students typing speed. Although there are many different influences, they found a negative relationship between essay time and typing speed for the same answer length. Brigham Young University researched students' essay exams to analyse grades, the length of the assessment response, typing speed, admission test scores and student demographics (Sloan, 2016). They established that longer essays are indeed graded higher than shorter answers. However, there was not a statistically significant relationship between typing speed and grades (Sloan, 2016). Students with higher undergraduate grades and higher admission scores achieved better grades, although they provided answers of similar length as their fellow students with lower credentials, indicating that the content of the answer, regardless of length, matters (Sloan, 2016).

Digital fluency is embedded in every method in contemporary teaching and learning. HEIs must ensure that criteria for fair assessment are met, irrespective of the technology and instrument used. How a student interprets or perceives an assessment, may render it fair or unfair. Stödberg (2012) highlights the importance of not disadvantaging students in the assessment procedure. Van der Westhuizen and Michael (2016) investigated the correlation between the performance of students and their digital fluency. They concluded that the use of technology for learning has very little or no impact on student

performance.

In addition to the quality control and certification of competency, learning evaluation influence student experiences as they learn and undertake assessments (Mimirinis, 2019). Marimuthu and Ramraj (2019) compared student perceptions using different assessments and confirmed that students value authentic e-assessments related to situations experienced in the real world. They believe that the evaluations also measure the students' ability to apply knowledge or skills, but more importantly, it is used as a vehicle for student learning.

2.4 Keyboard Fluency

Transcription fluency as a theoretical construct has been used to understand the impact of writing ability on student performance. Transcription fluency has been the focus of considerable theorisation and empirical research (Bennett et al., 2020). Cognitive theory posits that writing is composed of lower- and higher-level processes that compete for limited working memory. A writer can most effectively engage with higher-order processes like planning and revision, when lower-level processes like fluent transcription have been automatised. Studies using keystroke logs confirm and extend some of the results from cognitive research about transcription fluency (Van Waes & Leijten, 2015) and the relation between writing processes and composition quality (Bennett et al., 2020).

Cognitive writing theory based empirical research often relates keystroke log features to specific writing processes. Van Waes and Leitjen (2015) describe writing fluency from different perspectives. They measured students text production as a percentage of their maximum displayed ability over time using keystroke logging software. They showed how the writing production varies throughout the task. Their writing fluency model defined production (closely related to typing ability), process variance, revision, and pause behaviour as the four influences on the text produced by students (Van Waes & Leijten, 2015).

Guo et al. (2018) also noted that fluency features were associated with essay grades. Essays of students with shorter and less variable pauses between key presses within words are associated with higher scores. The theoretical understanding of transcription fluency in effective writing reinforces the importance of helping students develop higher competency levels, including typing skills, which should be an integral part of writing instruction (Bennett et al., 2020). However, where absent, it could introduce unfairness into assessments.

Gong et al. (2021) investigated the skill of producing text using a computer keyboard in the context of online-delivered writing tasks. They confirmed a non-uniform association between keyboarding skills and writing performance. Keyboarding fluency, a reliable individual-level attribute of a writer, has the strongest association with writing performance when writers fall below a critical threshold related to cognitive load. For fluent typists, the typing process for high-frequency words is probably automatised and less likely to be degraded due to other factors. However, for less fluent typists, the typing process, even for frequent words, is less automatic and are thus more likely to be degraded due to other factors (Gong et al., 2021).

3. Research Problem, Design and Methods

3.1 Research Problem and Objective

Researchers often present evidence that students achieve better grades in online assessments than physical assessments (Ali & Dmour, 2021) without questioning the complexity of the reasons for this difference. Therefore, online assessment construct validity remains a concern. Tertiary students are concerned about the impact of technical ability (Sharma et al., 2021) that could manifest as a lack of

time for assessments for potentially less technical proficient students (Ilgaz & Afacan Adanır, 2020) due to reduced keyboard fluency.

Educators need to ensure that students are not disadvantaged by any e-assessment procedure and that assessments are valid and reliable (Marimuthu & Ramraj, 2019). Technology should be used to support, and not impede, the learning process, including all forms of assessments. Fairness in assessment extends to students' expected use of technology and should not have a negative impact on their ability to demonstrate the attainment of learning outcomes (Ali & Dmour, 2021).

This research investigates the impact of the length of students' answers in essay type summative assessments, on the grades obtained in the evaluation. It examines if there is a demonstrable relationship between the length of answers and the grade received. Answer length (word count) is used as a proxy for digital competency to establish if digital competency influences student performance in e-assessments.

Although the length of a student's answer is not a perfect reflection of keyboard fluency, it is perceived as important by students and have been shown to impact answer length in time constraint environments. Student indicated that online assessments could be "unfair to those who are not good at typing" (Walker & Handley, 2015).

3.2 Research Design

Although using technology like keystroke loggers will enable a better indication of typing speed, Mohsen (2021) established that low time spent on word and character production can indicate good quality of writing. Using the length of a student's answer to a summative assessment as a proxy for digital ability is far from perfect. Still, it provides an acceptable measure and does not require the measurement of self-reported digital proficiencies or keylogging software. Keyboard fluency is one of the multiple skills that constitute students' technological proficiency, there is sufficient theoretical support for using this measurement.

A quantitative research approach making use of secondary data was used. First, sample data was collected from the Stellenbosch University Business School's MBA programme in South Africa. The data consisted of three different MBA courses and four different student cohorts who performed time constrained summative e-assessments. Although the students provided permission to use their data, it was decided not to disclose the nature of the usage or measure their digital proficiency directly since it may unfairly disadvantage students with perceived lower technical abilities. A systematic approach was followed using scatter plots, analysis of variance correlation testing, and regression analysis to examine the relationship between the length of an answer (word count) and the grade achieved for that answer.

3.3 Research Methods

The word count of answers from students that wrote summative e-assessments was calculated, and for each essay, the grade earned was extracted from the institution's academic database. Once the students were anonymised (a condition of ethical clearance), the word count and the grades were associated for analysis. After removing incomplete and duplicate records, all data points from the different courses and student groups were combined into a master data, set providing 393 observations for analyses.

Four different types of descriptive and inferential analysis were performed. First, a visual inspection was done by using a scatterplot. Then, following confirmation that there is an observable trend, the data were ranked from the lowest to highest test scores and then split into three groups, i.e., low-,

medium- and high-performance. Next, descriptive statistics were used to inspect the three groups by assessing boundary values, means and variance.

Inferential analysis using an analysis of variance (ANOVA) was done to test for statistically significant differences in the word count for the three groups of test scores. Finally, a simple linear regression was used to analyse the relationship between the independent variable (word count) and the dependent variable (test scores).

4. Research Results

4.1 Descriptive Statistics

A scatterplot was created to visually inspect the relationship between the variables of test scores (x) and word count (y) shown in Fig. 1. The scatterplot showed a moderate positive linear relationship between the two variables, providing the first indication of a potential positive association between word count and test scores.

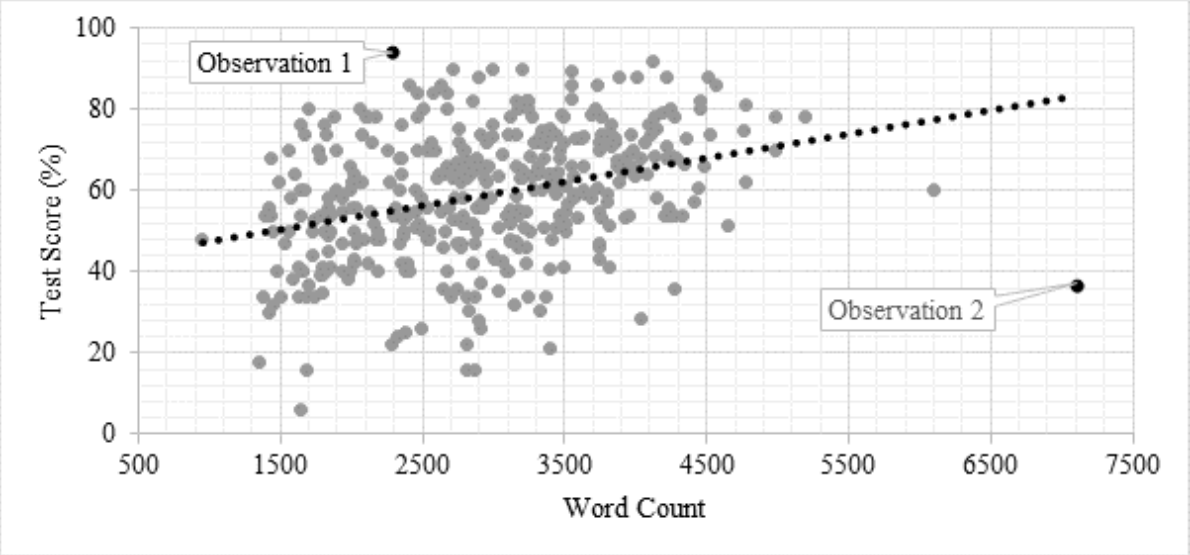

Figure 1: Scatterplot between pairs of test scores and word count values

To further investigate the observed relationship, the data set was ranked from lowest to highest scores and then divided into three groups, i.e., low-, medium- and high-performance. The results are shown in Table 1. The descriptive statistics indicate that the highest performing group also had the highest average word count (3 261) and the highest standard deviation (879) in the word count. Conversely, the lowest performing group had an average word count (2 570) significantly below the average word count (2951) of the combined group. This indicated further descriptive support for the proposition that word count affects student grades in line with expressed students' perceptions of typing speeds influencing the fairness of online assessments.

Table 1: Descriptive statistics of the word count of three groupings of students' results

Performance	Low	Medium	High	Combined
Lowest Score (%)	6	53	67	6
Highest Score (%)	53	67	94	94
Mean Score (%)	41,5	59,5	76,0	59,0
Score SD	9.5	4.3	6.4	15.8
Lowest Word Count	948	1 386	1 439	948
Highest Word Count	7 099	6 101	5 192	7 099
Mean Word Count	2 570	3 021	3 261	2 951
Range Word Count	6 151	4 715	3 753	6 151
Word Count SD	817	838	841	879
N	131	131	131	393

However, the lowest performance group also had the largest range (6 151) in word count and had the highest maximum word count (7 099), indicating that lengthy answers do not necessarily lead to good grades, as is evident from Observation 2 in Figure 1.

4.2 Inferential Statistics

An ANOVA test was used to determine a statically significant difference between the low, medium and high test scores between and within group means (see Table 2).

Table 2: One way analyses of variance (ANOVA) results

Groups	*Count*	*Sum*	*Average*	*Variance*
Low test score	131	33 6649	2 569.84	66 8104.6
Medium score	131	39 5795	3 021.336	702 901.1
High test score	131	427 177	3 260.893	708 000.9

Source of Variation	*SS*	*Df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	32 260 555	2	16 130 277	23.27594	2.82E-10	3.018862
Within Groups	2.7E+08	390	693 002.2			
Total	3.03E+08	392				

It follows from Table 2 that there is sufficient evidence to conclude that there is a significant difference in mean word count for the three different groups of student results at a 95% confidence level ($p<0.05$). Therefore, based on the difference between the means, it was decided to perform a regression analysis to determine the effect size of the difference.

Table 3 contains the results of the simple linear regression used to validate the relationship between the predictor (independent variable) of word count and the response (dependent variable) of test scores.

Table 3: Regression analysis for score and word count

Regression statistics	
Multiple R	0.3276565
R Square	0.1073588
Adjusted R Square	0.1050758
Standard Error	14.91621
Observations	393

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	41.6152	2.639	15.763	1.09E-43	36.424	46.805
Word count	0.0059	0.001	6.858	0.000	0.004	0.008

The coefficient of determination ($r^2 = 0.107$) indicates that word count only accounts for 10.7% of the variation in test scores, implying a weak association between the two variables. The correlation coefficient of 0.33 indicates a weak to moderate positive correlation between word count and test scores.

The regression equation was established as *Test score ($\hat{y}$) = 41.6 + 0.0059 words (x),* indicating that for each additional 100 words written, the grade of the student would potentially increase by 0.59%. The analysis also yielded a t-stat value of 6,858 and a p-value of approximately zero, confirming the positive statistical relationship between word count and test scores evident from the descriptive statistics.

5. Discussion of Results

Students have mentioned typing speed as a factor that may advantage some students during online assessments (Ali & Dmour, 2021; Hillier, 2014). Although typing rate does not necessarily lead to longer answers, it can be argued that online assessments provide the conditions for some students to create longer answers. However, while the average word count of the low-performance category of students was the lowest of the three groups, the range of word count values was the highest. Furthermore, the highest word count of all assessments fell in the poor performance group, indicating that longer answers can also result in poor scores. For example, a student in the high-performance group wrote as little as 1 439 words and that the top performing student wrote less than 2 500 words (Observation 1, Figure 1).

The analysis indicates that students can obtain high marks by creating concise answers. This is further evidenced by the fact that the high-performance group had the lowest maximum word count of all the groups and the smallest word count range. A high word count is not a prerequisite for a higher grade. Although word count as a proxy for generalised digital proficiency is only one dimension of technological competence, it can strengthen the generally held belief that online assessments can be unfair (Ndibalema, 2021; Sharma et al., 2021). The research is thus important in debunking this

generally held belief by students.

The inferential analysis confirms a statistically significant relationship between word count and test scores. However, the impact of word count on test scores is small. This is also evident when looking at the descriptive data and observing that the lengthiest answer from the entire data falls within the worst performing group (Observation 2, Figure 1). This study concludes that students without excellent typing skills are not significantly unfairly impacted by the use of e-assessments due to a lack of keyboard fluency in particular. It can be argued that a similar difference in handwriting speed existed before using e-assessments.

This research stops significantly short of presenting the definitive answer on whether generalised digital proficiency leads to construct irrelevance in online assessments. Other elements, such as whether a student is answering in their native language, critical thinking, creativity, innovation, analytical ability, and making inferences, could potentially impact student performance. In addition, the multiple tools available in e-assessments (like programs that review grammar and spelling) may help students. This is especially true when students answer questions in a non-native language to create better quality answers compensating for skills deficiencies not possible with handwritten tests.

Finally, it should be recognised that handwritten assessments are not without challenges. E-assessments also remove potentially distracting characteristics, such as handwriting quality and legibility. When assessments are typed, there are additional benefits that remove inherent bias embedded in handwriting and writing proficiencies preventing students from being unfairly disadvantaged.

6. Research Limitations

Apart from the sample limitations, there are limitations in the generalisability of the results. The study used word count as a proxy for keyboard fluency, an element of digital competency. The typing speed of each student was not measured but inferred from the number of words they submitted in their final answer for ethical reasons. It can be argued that students who knew they had a higher typing speed could spend more time analysing, planning and structuring their responses and thus create a higher quality answer, using fewer words. Although Bennet et al. (2020) observed a different process from students with higher typing speeds in compiling answers, they still submitted slightly more extended answers. However, it is possible that these students could spend more time planning and less time typing their final answers in line with the different elements of Van Waes and Leitjen's (2015) fluency model. This is not accounted for by the current research design.

The term e-assessment in this study refers to using digital technologies for summative essay type assessments. The more inclusive use of the term could include multiple modes of formative and summative assessments, using different modes of delivery and formats. These results should only be interpreted for essay based summative assessments under time constrained conditions.

7. Conclusion and Recommendations

7.1 Conclusions

Regardless of whether an assessment is designed for traditional classroom or online testing, the principles of assessment remain the same. Assessment instrument fluency will remain a critical factor in the perception of online evaluations by students. Assessment procedures and policies should reflect academic integrity and quality through a consistent, reliable, appropriate and systematic approach, which establishes if the assessment criteria have been met and if the required performance has been measured.

Students have varying attitudes about the transition to online assessment. One central claim from those with low acceptance of new technology was culture (Ndibalema, 2021). Students do not have the same exposure to technological systems in the South African context since they come from different socio-cultural contexts. Although the study demonstrates that a shorter answer, which may be attributed to slower typing, should not significantly disadvantage a student's performance, it does not mean that some students are not unfairly disadvantaged by e-assessments conditions.

Social justice and equality are criteria for effective assessment. However, not all students operate in a uniform setting. Access to faster devices, higher bandwidth and unlimited data (or lack thereof) can arguably create a more significant disparity between affluent and impoverished students when compared to a traditional classroom setting where students wrote assessments using pen and paper and had access to the same physical conditions during the evaluation.

7.2 Recommendations and Future Research

The findings allowed for generalisation about the relationship between test scores and the length of an assessment answer. Further investigation is required to explore the relationship linking test scores to students' access to digital resources, including the availability of devices and connectivity and a more comprehensive measure of digital proficiency. Additional moderating factors should be included to construct a more accurate model of technical factors impacting student test results.

Further analysis may ascertain which variables are directly and most reliably related to the test scores. This will assist educators and teachers in making informed decisions about the design of assessment methods. Considering the impact that technological changes have on the educational environment, higher education institutions and lecturers should continuously evaluate the suitability of the programme and module designed, inclusive of the assessment design.

8. References

Ali, L., & Dmour, N. A. H. H. Al. (2021). The shift to online assessment due to covid-19: An empirical study of university students, behaviour and performance, in the region of UAE. *International Journal of Information and Education Technology*, *11*(5), 220–228. https://doi.org/10.18178/ijiet.2021.11.5.1515

Alruwais, N., Wills, G., & Wald, M. (2018). Advantages and Challenges of Using e-Assessment. *International Journal of Information and Education Technology*, *8*(1), 34–37. https://doi.org/10.18178/ijiet.2018.8.1.1008

Alsadoon, H. (2017). Students' perceptions of e-assessment at saudi electronic university. *Turkish Online Journal of Educational Technology*, *16*(1), 147–153.

Amer, M. E. M. (2020). Effectiveness of Using Electronic Exams in Assessment in Saudi Universities: Empirical Study. *International Journal of Educational Technology and Learning*, *8*(2), 61–69. https://doi.org/10.20448/2003.82.61.69

Andrade, M. S., Miller, R. M., Kunz, M. B., & Ratliff, J. M. (2020). Online learning in schools of business: The impact of quality assurance measures. *Journal of Education for Business*, *95*(1), 37–44. https://doi.org/10.1080/08832323.2019.1596871

Bennett, R. E., Zhang, M., Deane, P., & van Rijn, P. W. (2020). How Do Proficient and Less Proficient Students Differ in Their Composition Processes? *Educational Assessment*, *25*(3), 198–217. https://doi.org/10.1080/10627197.2020.1804351

Crisp, G., Guàrdia, L., & Hillier, M. (2016). Using e-Assessment to enhance student learning and

evidence learning outcomes. *International Journal of Educational Technology in Higher Education*, *13*(1), 16–18. https://doi.org/10.1186/s41239-016-0020-3

Fluck, A., Adebayo, O. S., & Abdulhamid, S. M. (2017). Secure e-examination systems compared: Case studies from two countries. *Journal of Information Technology Education: Innovations in Practice*, *16*(1), 107–125. https://doi.org/10.28945/3705

Fluck, A., & Hillier, M. (2016). Innovative assessment with eExams. *Australian Council for Computers in Education*, *September 2016*. https://www.researchgate.net/publication/314352356_Innovative_assessment_with_eExams

Gong, T., Zhang, M., & Li, C. (2021). Association of keyboarding fluency and writing performance in online-delivered assessment. *Assessing Writing*, *September*, 100575. https://doi.org/10.1016/j.asw.2021.100575

Guo, H., Deane, P. D., van Rijn, P. W., Zhang, M., & Bennett, R. E. (2018). Modeling Basic Writing Processes From Keystroke Logs. *Journal of Educational Measurement*, *55*(2), 194–216. https://doi.org/10.1111/jedm.12172

Hammonds, F., & Mariano, G. (2015). Student test grades in college: A study of possible predictors. *International Journal of Teaching and Learning in Higher Education*, *27*(1), 114–118. http://search.proquest.com/docview/1720065996?accountid=14744

Hillier, M. (2014). The very idea of e-Exams : student (pre) conceptions Research context. *Proceedings of ASCILITE 2014Annual Conference of the Australian Society for Computers in Tertiary Education. Duneden, New Zealand*, *2014*, 77–88.

Ilgaz, H., & Afacan Adanır, G. (2020). Providing online exams for online learners: Does it really matter for them? *Education and Information Technologies*, *25*, 1255–1269.

Marimuthu, F., & Ramraj, U. (2019). An Authentic E-assessment Task. *Proceedings of the 2019 International Conference on E-Business and E-Commerce Engineering*, 41–46.

Mimirinis, M. (2019). Qualitative differences in academics' conceptions of e-assessment. *Assessment and Evaluation in Higher Education*, *44*(2), 233–248. https://doi.org/10.1080/02602938.2018.1493087

Mohsen, M. A. (2021). L1 versus L2 writing processes: What insight can we obtain from a keystroke logging program? *Language Teaching Research*, *preprint*. https://doi.org/10.1177/13621688211041292

Ndibalema, P. (2021). Online Assessment in the Era of Digital Natives in Higher Education Institutions. *International Journal of Technology in Education*, 443–463. https://doi.org/10.46328/ijte.89

Pennington, R. (2020). Assessment as Science and Story: A Roadmap for Christian Higher Education. *Christian Higher Education*, *19*(5), 365–384. https://doi.org/10.1080/15363759.2020.1712560

Sayed, M., & Baker, F. (2014). Blended Learning Barriers: An Investigation, Exposition and Solutions. *Journal of Education and Practice* , *5*(6), 81–85.

Shalatska, H. M., Zotova-Sadylo, O. Y., Makarenko, O. Y., & Dzeevytska, L. S. (2020). Implementation of formative assessment in higher education. *Proceedings of the 16th International Conference on ICT in Education, Research and Industrial Applications*, *29*, 79–86. https://doi.org/10.20419/2020.29.515

Sharma, A., Konar, K., Sanghvi, K., Churi, P., & Rao, N. T. (2021). Perception of Students in Online Test in Engineering: Case of NMIMS University. *IEEE International Conference on Communication Information and Computing Technology*, 1–7. https://doi.org/10.1109/iccict50803.2021.9510072

Sloan, K. (2016). *The Longer the Answer, The Higher The Law Exam Grade*. https://www.law.com/sites/almstaff/2016/09/27/on-law-school-exam-answers-the-longer-the-better/?slreturn=20201014142340

Stödberg, U. (2012). A research review of e-assessment. *Assessment and Evaluation in Higher Education*, *37*(5), 591–604. https://doi.org/10.1080/02602938.2011.557496

Van der Westhuizen, D., & Michael, L. (2016). *Correlating performance and digital learning habits in a higher-education institution*. http://uir.unisa.ac.za/bitstream/handle/10500/23427/Duan van der Westhuizen and Leoné Michaels.pdf?sequence=1

Van Waes, L., & Leijten, M. (2015). Fluency in Writing: A Multidimensional Perspective on Writing Fluency Applied to L1 and L2. *Computers and Composition*, *38*, 79–95. https://doi.org/10.1016/j.compcom.2015.09.012

Walker, R., & Handley, Z. (2015). Designing for Learner Engagement with e - Assessment Practices : The LE e - AP framework. *22nd Annual Conference of the Association for Learning Technology*, 1–18. http://humbox.ac.uk/5350/9/ALT2015_WalkerHandley_Designing_for_Learner_Engagement_with_e-Assessment_Practices.pdf

Evaluating the Ethical Implications of Using Chatbot Systems in Higher Education

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Abstract
Chatbot technology is rapidly evolving and being used for a variety of purposes, including education. This technology is utilized in the educational system for teaching and learning, counselling, evaluation, and research and development. Chatbots, as a technology that is increasingly infiltrating the educational sector, may have a direct impact on the lives and activities of students and faculty. As a result, an evaluation of these consequences is necessary. This paper seeks to evaluate the ethical implications of the use of Chatbots in tertiary education. A survey of 315 people was conducted. Many statistical analyses were performed on the collected data to achieve the expected results. The findings suggest that the employment of Chatbots in higher education has a practical substantial impact on users' privacy, transparency, and trust, as well as the digital gap.
Keywords: Artificial Intelligence, Chatbot System, Higher Education, Ethical Challenges, Students.

1. Introduction

One of the Artificial Intelligence (AI) powered technologies that has the potential of supporting educational activities is the Chatbot system or conversational agent. A Chatbot system is a Computer program that stimulate interactions with users through natural language (Murad, Iskandar, Fernando, Octavia, & Maured, 2019). It is an intelligent system that can communicate with students in form of questions and answers to provide correct response and promotes interactive learning (Ranoliya, Raghuwanshi, & Singh, 2017). Users communicate with chatbots via a basic text interface (Luxton, 2020). As chatbot technology progresses, more use cases emerge in practically every industry including education (Okonkwo & Ade-Ibijola, 2020). A Chatbot can be deployed to various channels such as Facebook, Skype, Mobile-Web, and so on, allowing users to use it on their preferred platform (SnatchBot, 2021). Chatbots are being used in education by students, teachers, and administrators, and the benefits are enormous.

The applications of Chatbot in education has revolutionised the education industry. Chatbots in education make learning more engaging and interactive as well as improving students learning capabilities. These AI-enabled technologies assist teachers in lowering the workload associated with daily duties such as assessing students' assignments and performance, content development and so on (Hien, Cuong, Nam, Nhung, & Thang, 2018). Administrators can utilize Chatbots to help with a number of automated operations, such as filing applications, collecting payments, assigning course schedules, providing answers to frequently asked questions (Hien et al., 2018; Ranoliya et al., 2017), and scheduling meetings (Okonkwo & Ade-Ibijola, 2020).

Chatbots in education can help students learn more effectively and supplement human intellect during the learning process, but they can also create ethical concerns (Hwang, Xie, Wah, & Gašević, 2020). Chatbots are a type of technology that has permeated human daily activities (Ruane, Birhane, & Ventresque, 2019). Users converse with Chatbots automatically by using natural language. As a result, the employment of Chatbots in education, in particular, poses certain ethical problems. Several studies have identified certain ethical concerns associated with the employment of a Chatbot system in educational settings, such as privacy, design methods, system personality, and trust and

transparency (Ruane et al., 2019), digital hegemony and digital divide (Hwang et al., 2020). These factors were mentioned but not empirically investigated. It is essential to understand the implications of these ethical issues on use of AI-assisted teaching and learning tools. The goal of this paper is to evaluate the ethical implications of using Chatbot systems in education. Therefore, the research question is "How does the user's ethics influence the use of chatbots in education?".
To address the research question, a survey was conducted using students and faculty at higher education institutions as sample population. Data were thoroughly extracted and analysed to obtain the required results.

Considering the studies that have highlighted the ethical issues associated with the usage of Chatbots in education, the contributions of this study are as follows. We have:

1. empirically examined the impact of ethical issues on the uses of Chatbots for educational purposes,
2. determined the extent of their influence on Chatbot adoption and use, and
3. suggested the possible ways to improve the development and use of Chatbot systems based on the ethical implications.

The remainder of this paper is structured as follows. Section 2 presents the background information, Section 3 describes the research methodology, and Section 4 discusses the data analyses. Section 5 explains the reliability analysis, Section 6 presents the survey results, and Section 7 interprets the results. Section 8 highlights the implications and Section 9 concludes the study.

2. Background Information

In this section, we present the theoretical information surrounding the topic under study including the use of Chatbots in education, identified ethical challenges, and the gap in the literature.

2.1 The Use of Chatbots in Education

A Chatbot system is an AI-powered technology that can communicate with users and provide accurate and instant answer. Several development platforms of frameworks can be used in the development of a Chatbot system including Microsoft Azure, SnatchBot, Google Dialogflow, IBM Watson etc. (Okonkwo & Ade-Ibijola, 2020; Pham, Pham, Nguyen, Nguyen, & Cao, 2018). These frameworks allow developers to construct Chatbot interactions that address a variety of educational issues. The increased use of technology in daily life is affecting how students learn and absorb knowledge. Educators may now provide a customised learning atmosphere for their students thanks to AI technologies – *Chatbot systems*. Chatbots are created to improve learning experience ad they are acting as a game-changer in the innovative age of the Fourth Industrial Revolution (4IR). Students are increasing using messaging system to interact with one another, as well as their teachers. The use of conversational agents in education provides individualized learning by adapting to the student's pace and demands, as well as their needs (Clarizia, Colace, Lombardi, Pascale, & Santaniello, 2018). The automation capabilities of chatbots assist teachers in reducing their workload and saves time thereby providing more 0pportunities for research, supervision, and counselling (Okonkwo & Ade-Ibijola, 2021). Chatbots applications in education enable democratisation of education because it does not consider the student location, resources, or language. In general, Chatbot systems provide fast and instant responses, individualised learning experience, automated task, and centralised learning.

2.2 Ethical Challenges in the Use of Chatbots in Education

The usage of chatbots in education has the potential to increase learning efficiency and strengthen student intelligence while studying, but it also has the ability to pose ethical concerns (Shum & Luckin, 2019). According to Luxton (2020), despite the possible benefits of using AI technologies, they pose some ethical challenges. As the educational system embraces conversational agents, there is

increasing growth in the development and adoption of these technologies resulting to some ethical questions (Ruane et al., 2019). Studies have highlighted some of these ethical issues without empirical investigation including privacy, design method, trust and transparency, and system personality (Luxton, 2020; Ruane et al., 2019), digital hegemony and digital divide (Hwang et al., 2020).

2.2.1 Privacy

The use of Chatbots entails collection of users' information. During the interaction between Chatbots and users, they system may collect some private and sensitive information of the users (Luxton, 2020). Collection of users data raises some ethical questions of "what type of data were collected, how are the data stored, what are the data used for, and how long will the data be stored?" (Ruane et al., 2019). Although there are data protection laws, but they vary among countries. The adoption and use of AI software tools involves some terms and conditions policy but users does not have the opportunity to negotiate it. Furthermore, most of the users of Chatbot systems are non-technical people, even though the technical individuals, as long as you are not the developer, you might not know what is happening in the technical level of the system – how the privacy of the users' information are managed (Luger & Sellen, 2016). As a result, privacy concept should be considered during development and adoption of Chatbot systems (Ruane et al., 2019).

2.2.2 Transparency and Trust

The status of a Chatbot as a non-human automatic system should be made known to the users. There is a difference between human-machine and human-human interactions (Mou & Xu, 2017). Users may make better decisions about their behaviour and information disclosure during conversations with a Chatbot system if they are aware that they are interacting with an intelligent agent rather than a human (Gentsch, 2019). This is especially significant when sensitive user data is being reviewed or disclosed, such as in the context of education. To avoid abuse of trust, it is essential to know the user's expectations from the Chatbot system and before the agent is released, reasonable expectations must be identified and verified (Ruane et al., 2019). Lack of transparency affects users trust in the AI technologies (Yu et al., 2018). Furthermore, Ruane stated that the requirements for users to trust a Chatbot system include explicitly explaining the system's motivation and behaviour, investigating how the system relates to different users, and understanding the users' experience, concerns, and anticipations.

2.2.3 Design Method

There are various types of Chatbots systems used for different purposes in the education domain. Each system has specific area of application, target users, and objectives. Understanding the application domain and the functions of a conversational agent will assist in identifying potential ethical challenges and solutions. A good design approach considers users characteristics, environment and activities (Ruane et al., 2019). Latham and Goltz (2019) reported that there were important differences between adult and children in the perception of privacy issues in the use of AI technologies. Incorporating such insight in the design of a Chatbot system will help in the considerations of ethical issues. As a result, there is no-one-fits all design standard or principles and variety of design methods is encouraged (Ruane et al., 2019).

2.2.4 System Personality

This involves the gender, ethnicity, age, culture, and class expressions of the Chatbot system. Most of the public Chatbot systems are present to be female such as Alexa, Apple Siri, and Google assistant(West, Kraut, & Chew, 2019). Male personalities are frequently encountered in authoritative contexts, such as an automated interviewer, and female personalities are frequently found in subservient scenarios (Tay, Jung, & Park, 2014; Zhou, Mark, Li, & Yang, 2019). In general domain such as banking, androgyny personality is preferred. According to Ruane et al. (2019) proposed using

androgyny personality in Chatbot design to avoid harmful gender stereotypes, and users should be able to define the system's personality, which may vary depending on the application context.

2.2.5 Digital Divide

There is a significant difference in the adoption of technological innovations between urban and rural dwellers (C. W. Okonkwo, M. Huisman, & E. Taylor, 2019). This differences may result in digital hegemonism (Hwang et al., 2020). The use of Chatbots in education depends on the affordability and accessibility of the systems to the students who may gain from them (Luxton, 2020). Adoption and use of AI technologies are hampered by a lack of technological infrastructure and affordability, particularly in remote areas with low-income populations (Organization, 2010). Also, inadequate ICT efficacy poses some challenges in the use of AI learning tools such as Chatbot systems (C. Okonkwo, M. Huisman, & E. Taylor, 2019) These factors raise some ethical concerns among the students of different background and abilities.

2.2.6 The Gap

According to studies, the usage of Chatbot systems promotes learning experiences and capacities while augmenting human intellect during the learning process, but it may also pose certain ethical concerns. (Hwang et al., 2020; Luxton, 2020; Ruane et al., 2019). These ethical concerns were raised and described without any empirical research. Evaluating these issues will help determine the extent to which they affect the use of Chatbot systems in education. This study aims to address this issue.

3. Methodology

The aim of this research is to examine the ethical implications of using Chatbots in education, thus, quantitative data is required. The positivism research principles were applied. A survey was done utilizing a questionnaire as the data collection tool to obtain self-determine data from participants without the involvement of the researcher.

3.1.1 Data Collection Instrument – The Questionnaire

A well-defined questionnaire with three sections was created, including personal information, Chatbot information, and ethical challenges. The questions are closed-ended, with a Likert scale of 1 to 5, with 1 indicating strongly disagreed and 5 indicating strongly agreed.

1) Personal details – this section gathers the participants information.
2) Chatbot information – this section investigates the participants' level of knowledge about the use of Chatbot system in education.
3) Ethical challenges – this section examines the implications of utilising Chatbots for educational purposes.

To verify that the questionnaire covered all the research objectives, a pilot test was conducted. The feedback received was considered, and changes were made as a result. The intended audience is students and teachers at tertiary institutions in South Africa, including the University of Johannesburg and several other institutes of higher learning. This demographic was chosen because students and faculty are likely to use conversational agents in the classroom. Because the researcher was unable to contact all potential participants, the convenience sampling technique was used in data collection. Convenience sampling is a data collection method that involves gathering information from individuals who are easily accessible within the target population (Okonkwo, Huisman, & Taylor, 2021a). The questionnaire was distributed using the online Google forms method. The online data collecting approach was only employed due of the current COVID-19 pandemic, which resulted in online learning and most of the personnel working from home. A total of 315 questionnaires were returned.

4. Data Analysis

The collected data was subjected to several statistical analyses using the SPSS 25 statistical software. Inferential statistics was used to describe the frequency of responses of the participants. The Cronbach reliability test was used to assess the reliability of the research constructs, with the minimum criteria coefficient alpha (α) of 0.6 (Sethi & King, 1991). Multi regression analysis was used to determine the practical significance of the challenges associated with the use of Chatbots in higher education.

4.1 Reliability Analysis

The results obtained from the reliability analysis show that the average α is 0.68. it implies that the questions in the instrument of measurement are reliable. Furthermore, the correlation scores of the items are equal (r=1), showing that the items are well correlated. The obtained results are possible because the research was carried out in a similar setting (educational institution) with similar participant perceptions. Table 1 displays the reliability results.

Table 1: Reliability analysis results

Research variables	Cronbach alpha
Privacy	0.73
Transparency and Trust	0.71
System Personality	0.64
Design Method	0.61
Digital Divide	0.72

5. Survey Results

The aim of the research is to evaluate the ethical implications of the use of Chatbots in higher education. The outcomes of the data collected are reported according to the three sections of the questionnaire as described below.

Participants' details – Students and faculty from South African tertiary institutions including the University of Johannesburg and other institutions of higher learning participated in the survey. A total of 315 participants were involved in the survey including Male (60%) and female (40%), students (50%), staff (40%), and others (10%). Others are the group of individuals that are neither students nor staff of educational institution, but they have used a Chatbot systems. The participants are within the age group of 15-25 (40%), 26-35 (10%), 36-45 (25%), 46-55 (20%), and 56-65 (5%).

Chatbot information – 80% of the participants agreed that they know what a Chatbot system is all about, 10% does not know what a Chatbot is, and 10% were indifferent. 75% of the participants have used a Chatbot system, 10% have never interact with a Chatbot, and 15% could not determine if they have ever use a Chatbot system. 50% of the participants agreed indicated that they used Chatbot systems for learning, 35% for teaching, 10% for customer services, and 5% for counselling.

Ethical challenges – The data obtained from the part of ethical challenges are described as follows.
Privacy – 65% of participants agreed that they entered their personal details while using a Chatbot system, 15% disagreed, and 20% are neutral to this aspect. 70% of the participants believed that they do not know how their personal data given to the Chatbot are being used, 10% disagreed, and 20% were indifferent. Also, 80% of the participants were worried about the disclosure of their private information to a machine, 5% were not worried, and 15 were neutral.

Transparency and Trust – These measures the identity of a Chatbot, the motivation of using a Chatbot, and the extent of trust on the responses received from a Chatbot system. 40% participants agreed that they know that a Chatbot is not a human, 25% does not know, and 35% were indifferent. In knowing the motivation of a conversation with a Chatbot, 25% accepted that they are completely aware of the purpose of their interaction with a Chatbot, 25% does not know, and 50% were neutral. Regarding trust, only 25% agreed that they trust the responses from the Chatbots, 50% disagreed, and 25% were indifferent.

Design method – 60% of the participants believed that if they understand the main functions of a Chatbot, they can easily use adopt and use, 15% do not believe on this aspect, and 25% were neutral. *System personality* – measures the gender representation of a Chatbot. 43% saw a Chatbot as a female agent, 41% saw it as a male agent, and 16% assumed that it can either be male or female.

Digital divide – This challenge measures the feelings of the participants regarding the availability of necessary infrastructure need to use a Chatbot system. 65% of the participants believed that they cannot afford the use of a Chatbot, 10% can afford the use, and 25% were neutral. Also, 50% of the participants said that there is no network coverage in their area, 10% agreed to have a good network connectivity, and 40% were indifferent.

Furthermore, a Multi regression analysis was carried out to determine the practical significance of the ethical challenges associated with the use of Chatbots in higher education. Table 2 shows the results obtained.

Coefficients

Model	B	Std. Error	Beta	t	Sig.	Tolerance	VIF
(Constant)	3.187	.126		25.939	.000		
Privacy	.098	.028	.124	3.990	.000	.786	1.272
Transparency and Trust	.074	.030	.077	2.442	.015	.762	1.313
System personality	.048	.029	.047	1.565	.118	.821	1.218
Design method	-.008	.026	-.010	-.316	.752	.790	1.265
Digital divide	-.101	.029	-072	-3.718	.012	-758	1.297

6. Interpretation of Results

The research was carried out in higher educational context with significant proportions of different gender components (male (60%) and female (40%)), covering students and faculty in the institutions. This implies that the gender components are well represented., and the result is consistent with the report that mobile applications are adopted and used by everyone, regardless of gender (C. W. Okonkwo et al., 2019). Most of the participants were between the ages of 15 and 35, indicating that substantial proportion of the people participated in the study are students. The results show that the vast majority of the sampling population has a good understanding of what a Chatbot system is and has used Chatbot systems for various purposes. Most of them used Chatbot systems for teaching and learning. It implies that the participants have sufficient knowledge to provide the necessary responses that may yield adequate results. The findings revealed that the applications of Chatbot systems in higher education present some ethical challenges on the user privacy, transparency and trust, system personality, design method, and digital divide. This result compares well with the reports of previous studies that highlighted the potential impact of ethical issues on the applications of Chatbot technologies in education, though without empirical evaluation (Hwang et al., 2020; Luxton, 2020; Okonkwo, 2019; Okonkwo & Ade-Ibijola, 2021; Okonkwo, Huisman, & Taylor, 2021b; Ruane et al., 2019).

In the context of this study, privacy is the ability to preserve the personal information given to a Chatbot during conversation. The interaction with a Chatbot may require the user to provide his/her private information and a large number of the participants agreed that they used to enter their personal or private information while using a Chatbot system. This raises some questions such as "What happens to this sensitive information?" It is important to know how the system make use of the data collected form the users. The results from the investigation revealed that user used to provide their personal data on the course of interactions with the system and they do not know how the data is stored and what they used for. Because of the sensitivity of the information, they are worried about the disclosure of the information. User information is paramount and need to be mange properly, especially in the applications of Chatbots in higher education and it is not only affecting an individual but entire social system (Ruane et al., 2019).

In terms of transparency and trust, the results show that a smaller proportion of users understand that they are interacting with a machine during a conversation with a Chatbot, while most of them are frequently perplexed. This possible because Chatbot is an Artificial Intelligence (AI) that mimic human (Adamopoulou & Moussiades, 2020; Ranoliya et al., 2017). Also, the finding shows that the users' expectations are not completely covered by the Chatbot. As a result, users do not have complete trust on the response obtained from the system. It is critical to have a good understanding of what the users want in order to gain their trust. As a result, before releasing a Chatbot, it is necessary to properly evaluate and specify the users' expectations (Ruane et al., 2019). Thus, if students and faculty lack confidence in the capabilities and functionality of the Chatbot system, adoption and use of the technology will be hampered.

Concerning the design method, Chatbot is a computer program developed and deployed into mobile web. The presentation of various Chatbot systems appears as if their design methods are the same. The results from the analysis revealed that many participants agreed that the design of Chatbots is confusing, and that if they understand the application domain and key objectives of a Chatbot, they can easily adopt and use it. Having the knowledge of the application area and the task of a Chatbot will help the users to identify possible ethical challenges and solutions (Latham & Goltz, 2019; Ruane et al., 2019).

Regarding the system personality, a Chatbot may interact with people through voice messaging. The voice might be male, female or androgyny. This voice associates with race and culture. The findings indicate that users perceive a Chatbot to be either male, female, or both. The personality of the system may influence the users' decision during a conversation with the system. Making a Chatbot with a specific personality may disrupt users' perceptions, which may lead to bias in Chatbot adoption. It is important to examine the effect of the system personality on the types of interactions users might desire to have with the Chatbot, as well as to determine whether the design of the system personality and related conversation may lead to harmful behaviour (Ruane et al., 2019).

As far as digital divide is concern, the possible benefits of using Chatbot technologies in educational activities can only be realised if they are made available to those who could benefit from them. Use of a Chatbot requires technological infrastructure such as network connectivity and internet data. Lack of these requirements hamper the adoption and use of the system. According to the findings of this study, users are willing to use a Chatbot if they have adequate technological structures and can afford the cost of data. A student in a remote location will be depressed if these requirements are not met, which may raise ethical concerns. Lack of adequate technological infrastructure may result in digital divide (Hwang et al., 2020) and use of technologies depends on affordability (Luxton, 2020).
A Multi regression analysis was conducted to determine the practical significance of the ethical issues associated with the use of Chatbots in higher education. According to Ellis and Steyn (2003), the

criteria for practically significance is that p-value < 0.05. Three areas of the ethical challenges including privacy, transparency and trust, and digital divide have p-values less than 0.05. The findings suggest that the employment of chatbots in education has a practically significant effect on users' privacy, transparency, and trust, as well as the digital divide. The results explained that the usage of Chatbots, particularly in higher education, has a significant potential for exploiting users' private information, and that poor clarity in Chatbot creation may lead to a loss of confidence in utilising a Chatbot. Furthermore, a lack of technological infrastructures and the unaffordability of internet connections may promote social differences, leading to ill-feelings toward the social system's remote dwellers. It is, therefore, evident that ethical challenges affect the use of Chatbots technology in education.

7. Implications

The ethical challenges posed by using Chatbots in higher education have been evaluated and discussed. It indicates that these challenges may skew users' perception, limiting the use of Chatbot systems in educational domain. To increase the adoption and use of Chatbots or conversational agents in education, scholars and stakeholders must specify suitable solutions that can help to reduce the negative impacts of these challenges including:

1. The development of standard design and application principles as well as practical recommendations to serve as guidelines for the creation, adoption, and use of Chatbot systems. We therefore, agreed with the suggestion of (Luxton, 2020) who recommended for the creation of new ethics rule for practical implementation of conversational agents.

2. Also, increasing public awareness of the benefits of using Chatbot systems in higher education will help to increase user interest in using AI technologies.

8. Conclusion

The purpose of this research work is to evaluate the ethical implications of the use of Chatbots in higher education. A quantitative research approach was applied through a survey. Various types of statistical analyses were carried out on the collected data to achieve the required results. From the participants point of view, Chatbot system is a known technology that is in use actively in higher education mostly for teaching and learning. The empirical results of inferential statistics indicated that the use of Chatbots in higher education poses certain ethical issues in some areas such as user privacy, transparency and trust, system personality, design method, and digital divide. Moreover, results from multi regression analysis indicated that the use of Chatbot in education have practically significant impact on users' privacy, transparency and trust, and digital divide. The findings implies that these challenges may bias the users' perception and limit the use of Chatbots in higher education. Adequate solutions, such as well-defined usage policies and spreading knowledge about the benefits of employing Chatbots in tertiary education, may aid in reducing the difficulties that may arise as a result of these ethical challenges.

9. References

Adamopoulou, E., & Moussiades, L. (2020). *An overview of chatbot technology.* Paper presented at the IFIP International Conference on Artificial Intelligence Applications and Innovations.

Clarizia, F., Colace, F., Lombardi, M., Pascale, F., & Santaniello, D. (2018). *Chatbot: An education support system for student.* Paper presented at the International Symposium on Cyberspace Safety and Security.

Ellis, S., & Steyn, H. (2003). Practical significance (effect sizes) versus or in combination with statistical significance (p-values): research note. *Management Dynamics: Journal of the Southern African Institute for Management Scientists, 12*(4), 51-53.

Gentsch, P. (2019). Conversational AI: how (chat) bots will reshape the digital experience. In *AI in marketing, sales and service* (pp. 81-125): Springer.

Hien, H. T., Cuong, P.-N., Nam, L. N. H., Nhung, H. L. T. K., & Thang, L. D. (2018). *Intelligent assistants in higher-education environments: the FIT-EBot, a chatbot for administrative and learning support.* Paper presented at the Proceedings of the ninth international symposium on information and communication technology.

Hwang, G.-J., Xie, H., Wah, B. W., & Gašević, D. (2020). Vision, challenges, roles and research issues of Artificial Intelligence in Education. In: Elsevier.

Latham, A., & Goltz, S. (2019). *A Survey of the General Public's Views on the Ethics of Using AI in Education.* Paper presented at the International Conference on Artificial Intelligence in Education.

Luger, E., & Sellen, A. (2016). *" Like Having a Really Bad PA" The Gulf between User Expectation and Experience of Conversational Agents.* Paper presented at the Proceedings of the 2016 CHI conference on human factors in computing systems.

Luxton, D. D. (2020). Ethical implications of conversational agents in global public health. *Bulletin of the World Health Organization, 98*(4), 285.

Mou, Y., & Xu, K. (2017). The media inequality: Comparing the initial human-human and human-AI social interactions. *Computers in Human Behavior, 72*, 432-440.

Murad, D. F., Iskandar, A. G., Fernando, E., Octavia, T. S., & Maured, D. E. (2019). *Towards smart LMS to improve learning outcomes students using LenoBot with natural language processing.* Paper presented at the 2019 6th International Conference on Information Technology, Computer and Electrical Engineering (ICITACEE).

Okonkwo, C., Huisman, M., & Taylor, E. (2019). *Socio-Economic Contributions of Mobile Applications in Africa: Impact of Local Mobile Applications.* Paper presented at the 2019 International Multidisciplinary Information Technology and Engineering Conference (IMITEC).

Okonkwo, C. W. (2019). *An investigation on the adoption and diffusion of mobile apps in Africa.* (PhD Thesis), North West University, Potchefstroom Campus,, South Africa.

Okonkwo, C. W., & Ade-Ibijola, A. (2020). Python-Bot: A Chatbot for Teaching Python Programming. *Engineering Letters, 29*(1).

Okonkwo, C. W., & Ade-Ibijola, A. (2021). Chatbots applications in education: A systematic review.

Computers and Education: Artificial Intelligence. doi:https://doi.org/10.1016/j.caeai.2021.100033

Okonkwo, C. W., Huisman, M., & Taylor, E. (2019). *The adoption of m-commerce applications: rural dwellers perspectives.* Paper presented at the 12th, IADIS, International conference. Information systems.

Okonkwo, C. W., Huisman, M., & Taylor, E. (2021a). Effect of Homegrown Mobile Applications on Africa's Development: Comparative Analysis. *IEEE Transactions on Computational Social Systems*.

Okonkwo, C. W., Huisman, M., & Taylor, E. (2021b). Factors that influence Africa's refusal and discontinuation of mobile applications use. *African Journal of Science, Technology, Innovation and Development*, 1-10.

Organization, W. H. (2010). *Telemedicine: opportunities and developments in member states. Report on the second global survey on eHealth*: World Health Organization.

Pham, X. L., Pham, T., Nguyen, Q. M., Nguyen, T. H., & Cao, T. T. H. (2018). *Chatbot as an intelligent personal assistant for mobile language learning.* Paper presented at the Proceedings of the 2018 2nd International Conference on Education and E-Learning.

Ranoliya, B. R., Raghuwanshi, N., & Singh, S. (2017). *Chatbot for university related FAQs.* Paper presented at the 2017 International Conference on Advances in Computing, Communications and Informatics (ICACCI).

Ruane, E., Birhane, A., & Ventresque, A. (2019). *Conversational AI: Social and Ethical Considerations.* Paper presented at the AICS.

Sethi, V., & King, W. R. (1991). Construct measurement in information systems research: An illustration in strategic systems. *Decision Sciences, 22*(3), 455-472.

Shum, S. J. B., & Luckin, R. (2019). Learning analytics and AI: Politics, pedagogy and practices. *British journal of educational technology, 50*(6), 2785-2793.

SnatchBot. (2021). Education — Enhancing the Classroom with Chatbots. Retrieved from https://snatchbot.me/education

Tay, B., Jung, Y., & Park, T. (2014). When stereotypes meet robots: the double-edge sword of robot gender and personality in human–robot interaction. *Computers in Human Behavior, 38*, 75-84.

West, M., Kraut, R., & Chew, H. E. (2019). I'd blush if I could: closing gender divides in digital skills through education.(2019). In.

Yu, H., Shen, Z., Miao, C., Leung, C., Lesser, V. R., & Yang, Q. (2018). Building ethics into artificial intelligence. *arXiv preprint arXiv:1812.02953*.

Zhou, M. X., Mark, G., Li, J., & Yang, H. (2019). Trusting virtual agents: The effect of personality. *ACM Transactions on Interactive Intelligent Systems (TiiS), 9*(2-3), 1-36.

Didactics has evolved to digital age didactics

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Abstract
Didactics has evolved from pre-didactics, didactics-dialectics, classical or traditional didactics and now to digital age didactics. However, few studies allude to the significance of this evolution. We present a case study of digital age didactics of student-teachers exploration using the virtual class platform to discover prominent female mathematicians. With ethnographic analysis of the results, it was discovered that student-teachers successfully employed the platforms to plan and design, teach and learn, diagnose problems, and participate in virtual activities. We concluded that the framework was suitable as it allowed for collaboration, participation and innovation. We therefore recommended that all assessment for, assessment as and assessment of criteria be channelled into digital age didactics.
Keywords: didactics; digital age, assessment as learning, assessment for learning, assessment of learning

1. Focus of the Study

Over several decades, didactics has evolved mainly from pre-didactics stage through the didactics-dialectics stage to classical didactics stage. Broadly speaking, the main stages of evolution of didactics are pre-didactics, didactics-dialectics, classical didactics and digital age didactics. The pre-didactics stage began with Socratic dialogues and later transformed to the Socratic method of teaching of classical fine arts curricula. So, the two major blocs of trivium and quadrivium emerged. The didactics-dialectics stage began with the study of reading and further continued with dialectics. In dialectics, classrooms are perceived as art of teaching. The classical or traditional didactics began with the transition from the art to the science of teaching and learning (Ali & Davis, 2020; Kjellsdotter, 2020).

2. Relevance of the Study/Contribution to Knowledge

Digital age didactics begins with reconceptualization and reconstruction of classical didactics in the era of Information and Communication Technologies (ICT) (Jahnke, Norqvist, & Olsson, 2013; Jahnke et al., 2014). The stages of pre-didactics and didactics-dialectics see the emergence of the first teaching method (e.g., Socratic dialogue), curriculum (e.g., Classical Fine Arts) and dialectics (e.g. digital Technology innovations in mathematics instruction). The stages of didactics-dialectics and classical didactics witnessed the emergence of didactics fields, theories, frameworks and models for teaching and learning (Jackson, 2017). However, the current emergence of didactics to digital age didactics ensures quality innovations in teaching, learning and assessment of mathematics instruction through ICT-based learning artefacts. These artefacts range from simple calculators, smart phones to laptops and personal computers among the various electronic and social media (Kjellsdotter, 2020). The new Ghanaian curricula encourage the use of digital artefacts and internet learning, teaching and assessment (Ministry of Education, 2020; Akayuure, 2021). This will ensure all embracing and lifelong learning.

This study is particularly significant and contributes immensely to the theoretical, methodological and practical knowledge of evolution of didactics of mathematics in the Sociocultural Framework for Understanding Technology Integration (Jackson, 2017; Kjellsdotter, 2020). This framework views teaching, learning and assessment as an interaction between societal and environmental factors within and outside of the classroom. This interaction promotes understanding of the factors effecting integration of technology into mathematics classroom (Goos & Bennison, 2019). This is an extension

of Valsiner (1997) theory of Vygotsky's concept of Zone of Proximal Development (ZPD) to the Zone of Free Movement (ZFM) and Zone of Promoted Action (ZPA). Jackson (2017) opines that ZPD describes the gap between current and potential capabilities of learners that can be traversed with appropriate support. But are ZFM and ZPA are sub-theoretical frameworks within ZPD. While ZFM takes good care of the constraints that affect the ways an individual can interact with their environment, and ZPA simply describes the efforts of an experienced learner, who is developing his/her new skills. In much simpler analogy, while ZPD itself allows one to experience mathematics pedagogy, pedagogical beliefs and technological experiences, ZFM describes the ICT access, attitudes and ability in teaching, learning and assessment (Goos & Bennison, 2019).

3. Methodological Approach Adopted

The case study based qualitative methodology with an ethnographic approach was adopted from Hernández-Carranza et al. (2015) and Kjellsdotter (2020). The case study methodology focused on people's actions on a small-scale and in an everyday context, which is suited to qualitative ethnographic work (Kjellsdotter, 2020). This means the study was purely based on analysis of observations rather than experiments, in words and images rather than numbers, and in inductive, hypothesis-generating research rather than hypothesis testing (Kjellsdotter, 2020). Furthermore, the analysis involved an interpretation of human actions and the school practice, as well as implications for a wider context (Kjellsdotter, 2020). The case study design was deemed the best and most appropriate design for these actions.

The ethnography was a particularly appropriate method for teaching, learning and assessment because the model has strong similarities between the way people teach, learn and assess instruction via the internet. Ethnography usually involves the researchers participating over an extended period of time, watching, listening, asking questions, collecting documents (Kjellsdotter, 2020). This means that the researcher must be prepared to consider many different types of data and be engaged in the material. This really involves time investment and mutually trustful human connection with the participants (Kjellsdotter, 2020). Therefore, the researchers ensured that the research methods used in the study had long-term observation of classroom practice, formal and informal interviews with student-teachers in the university (Ruthven, 2013).

4. The Study Setting

The study took place in the Department of Basic Education, University of Education, Winneba in Ghana. The actual participants consisted of 168 student-teachers; 130 women and 38 men. . The study focused on the tasks involving the use of internet to generate a list of award winning and prominent women scientistsThe overall study focused on the work of using the internet to generate important women scientists. Over During the three weeks of interactions, student-teachers presented different internet search results individually, in groups and as whole-classon preparations and demonstrations which were the basis for the empirical datathere were different classroom assignments involving individual, group and whole-class work, which was the basis for the empirical data, on the student-teachers preparations and demonstrations in whole-class activities and individual work. The tasks they carried out sought to use the internet for collecting artefacts in groups of ten, and in individual work about women who have distinguished themselves in STEM domains, some of whom must be Africans. Out of the ten student-teachers in a group, each person was required to create a virtual portfolio of at least one prominence woman scientist in Africa and later print and laminate the collection as an albumOut of the ten student-teachers in a group, each person was required to create and laminate at least one important woman scientist. The main aim of this setting was not only to create albums but also offer the student-teachers an opportunity to use the internet to perform teaching, learning and assessment. The main aim of this setting was not only to create albums but also offer the student-teachers an opportunity to learn how to surf the internet, teach their students to search the net and finally assess students search outcomes. The virtual platform for creating and dissemination of the

virtual portfolios was the UEW official Learning Management System called UEW Vclass (https://vclass.uew.edu.gh/login/index.php). The essence was to move the student-teachers' knowledge of the usual traditional didactics to digital age didactics. The main platform for creating and dissemination of the information was the University's learning management system and the social media platforms. These further moved the student-teachers knowledge from didactics to digital age didactics.

5. Data Collection

The data was collected through classroom observations, formal and informal interviews, representations of work and local policy documents. These different data collections of descriptive field notes, documents and interviews, were later processed and analysed for the purpose of interpreting student-teachers' interaction with ICT in relation to digital age didactics research (Jahnke & Norberg, 2013). The data collection began with observation of many different features, observing the kinds, models and types of digital tools available to the student-teachers. The main tools were smart phones, laptops, desk top computers and smart calculators. The varied tools gave the work rich data. It also gave more and comprehensive details on student-teachers knowledge and practices of digital age didactics (Perri, 2018).

6. Data Analysis

The analysis of the teaching, learning and assessment in the framework of age digital didactics mainly occurred in four areas, namely dissemination, discussion, discovery and demonstration. With regard to the demonstrative phase, the researchers created a digital assessment frame, organized into three stages, such as an initial diagnosis, a formative intermediate analysis and a final test. The other three stages (discussion, discovery and demonstration) were performed with the use of the university learning management system software (Perri, 2018).

Finally, the assessment questions were shared on the LMS platforms in real time so that student-teachers gradually monitor and observe the co-building of their knowledge. The general evaluation frame was designed as an assessment system *for* learning, *of learning* and *as* learning (Ministry of Education, 2020). In this way, participants were not only directly engaged in the evaluation process, but through their own metacognition, critical thinking and collaboration they also experienced how to use the LMS to create a digital set of artefacts to support their future digital didactics (Perri, 2018).

7. Teaching and Learning

Generally, McLaughlin (2018) defines digital education as the innovative use of digital tools and technologies during teaching and learning, and is often referred to as Technology Enhanced Learning (TEL) or e-Learning. This suggests that the use of digital technologies provides educators with the opportunity to design learning opportunities for teaching. These opportunities can be a blended or fully online course (McLaughlin, 2018). This means exploring the use of digital technologies gives educators the opportunity to design engaging learning opportunities in the courses they teach, and these can take the form of blended or fully online courses and programmes (McLaughlin, 2018). Therefore, the researchers used Digital Teaching and Learning to offer the student-teachers the opportunity to delve into deeper exploration of mathematics concepts discovered by distinguished women in STEM (Hegedus, et al., 2016)In furtherance to this, the researchers used Digital Teaching and Learning to offer the student-teachers the opportunity to delve into deeper exploration of mathematics concepts discovered or innovated by distinguished women in STEM teaching and learning (Hegedus, et al., 2016). This helped the researchers to properly locate the study in relation to the intersection of research, theory and teaching practice (Lütge & Merse, 2020).

8. Assessment-Formative and Formative

During the sessions, participants were asked to self-evaluate the course through formative assessment. The comments and criticisms obtained were crucial to define the further session's management. Then they defined the general features of the digital didactics environment they would like to meet and solve the problems. In summative assessment, student-teachers were required to co-create and compile final albums of pictures containing female scientists. At this point, all the digital didactics works had been shared on the LMS vclass platform. The participants were then required to comment on their most favourite female scientists.

9. Ethical Considerations

This study followed the basic ethical principles (Honesty; Openness; Orderliness; Consideration; Impartiality). In order to conduct the study, permission from the participants was necessary (Cohen et al., 2011). The participants were informed orally about the study, in class before the data collection. In these cases, the researchers were not only dependent on permission from the student-teachers but also followed the UN Convention on the Rights of the Child (Heath et al., 2010). In this study, it was necessary to explain the purpose of our presence in the class and to obtain approval from the student-teachers. All student-teachers approved the study except those who were absent from class.

Our role as participatory observers could be described as another adult in the classroom without responsibilities. The study was overt and the student-teachers were informed of the intentions of the study and our role as researchers in the room. However, as responsible adults there could have been situations in which we had to consider how to act in overhearing that student-teachers downloaded obscene and pornographic materials from the internet. In such cases, we helped avert the ethical principles of *harm to participants* (Heath et al., 2010).

During the participatory observations, we had always availed ourselves to the class and no situations occurred in which we had to abstain from class. However, there were situations where we undertook video recordings in many circumstances unproblematic. In these cases, the researchers were not only dependent on permission from the student-teachers but followed the UN Convention on the Rights of the Child (Heath et al., 2010). In this study, it was necessary to explain purpose of our presence in the class and to obtain approval from them. All of them did approve our research except truant and absentee ones.

Another aspect was whether there was *invasion of privacy* linked to informed consent, in that the participants must have a detailed understanding of what their participation in the research was likely to entail. As stated earlier, our intension was not only made overt but explicit and congenial manner. The ethics on confidentiality states "that the identities and records of individuals should be maintained as confidential" (Kjellsdotter, 2020). So, during our presence in the class, we obtained assured participants of our resolve to seal whatever information we obtained them and we would use the information for only this study.

10. Results

Participants' portfolios and album were examined to highlight various collection of women scientists, their countries and workplace. Table 1 shows the result of our analysis.

Table 1: Ten selected African female mathematicians

Female Scientist	Country	Work
Hypatia De Alexandria	Egypt	Ship Navigation
Yewande Olubummo	Nigeria	Doctoral Organizer
Verdiana Grace Masanja	Tanzania	African Mathematic Union
Marian Ewurama Addy	Ghana	Head of Mathematics
Rosina Mamokgethi Phakeng	South Africa	Mathematics Research
Evelyn Boyd Granville	African-American	Mathematics Education
Eunice Gogo Mphako	Malawi	Mathematics Lecturer
Hajer Bahour	Tunisia	Partial Differential Equations
Marie Francisco Ouedraogo	Burkina Faso	Triple Superalgebra
Rebecca Walo Omana	DRC	Ordinary Differential Equations

In Table 1, the student-teachers discovered among other personalities noble African female mathematicians that have made immersed contributions to the study of mathematics. Even though the list was endless it was so revealing to observe that there are so many female mathematicians whose names remained hidden and in the shelves. But for no digital age didactics the student-teachers could not have noticed these personalities who could serve as their motivation, mentors and role models. Teaching this class that has majority female student-teachers was a necessity and thought provoking.

11. Interesting Remarks

Group 'A': *Hypatia De Alexandria is the first female mathematician whose life is reasonably recorded*.
Student 'B': *Marian Ewrama Addy has received the millennium excellence awards for educational development in science, mathematics and technology in Ghana*.
Syudent 'C': *Nancy Refilwe Phaswana-Mafuya has distinguished herself in epidemiology, research and innovation*.

The above statements and many found on Table 1 show that the student-teachers really explored the digital age didactics to enhance knowledge and theory.

11.1 Key Findings

a) Planning and design: It was observed through the activities analysed and tested during the vclass sessions that the use of digital didactics improves curricular planning and design. A noteworthy fact is that the participants declared themselves competent to develop activities such as defining gender, strategy in downloading pictures from search engines, identifying vclass features, drawing up a teaching strategy for incorporating vclass, printing, dissemination and implementation their own ideas via vclass of LMS (Akayuure, 2021).

b) Teaching and learning. When analyzing how the participants produced didactic resources using digital didactics technology, the results show that the majority believe the objective of teaching

Mathematics via digital resources was necessary and plausible for themwas important whereas the number of some previous experience in virtual learning settings although only 5% had had previous experience in virtual learning settings done an LMS before (Lütge & Merse, 2020).

c) Diagnostic assessment: In the assessment session, student-teachers utilized many skills of digital didactics to discover, create and innovate artefacts from the LMS vclass. This helped not only learn to teach but also to assess themselves in the process of teaching, learning and assessment (Perri, 2018).

d) Use of LMS platform. Concerning the advantages of using vclass, the information compiled shows that student-teachers developed research skills and critical thinking as well as greatly motivated their participation (McLaughlin, 2018). However, it is worth mentioning that a small percentage of the student-teachers believed that LMS can impede the teaching and learning process (Kjellsdotter, 2020).

e) Participation on the vclass. Our interaction with participants revealed that most student-teachers were partially or totally in favour of digital didactics. The student-teachers declared themselves partially or totally in favour of digital didactic pedagogical principles. The student-teachers indicated that identified the advantages of vclass are student-centeredness, participation and interaction. The interactions can take place in different forms which are accessible and cost-free and ensures autonomy in learning and access to the pictures can take place on various platforms and in different forms, using different apps, are accessible and cost-free, autonomy in learning, and access to the pictures (Ali & Davis, 2020). For the student-teachers, the most relevant contribution of the vclass was the knowledge they acquired and personal training while the least significant factors were network and socialization with material. In fact, clarity of instructions was the most recurring difficulties for the student-teachers are student-centeredness, participation and interaction can take place on various platforms and in different forms, using different apps, are accessible and cost-free, autonomy in learning, and access to the pictures (Ali & Davis, 2020). For the student-teachers, the most relevant contribution of the vclass was the knowledge they acquired and personal training while the least significant factors were network and socialization with material. In fact, clarity of instructions was the most recurring difficulties for the student-teachers.

12. Conclusions and Recommendations

In conclusion, the results show that digital age didactics can be a suitable innovative way to teaching, learning and assessment of mathematics instruction. In conclusion, the results show that digital age didactics as an innovation to teaching, learning and assessment of mathematics instruction is very suitable for the design and use for teaching, learning and assessment. Digital age didactics should be used to innovate mathematics instruction and motivate learning. Particularly, student-teachers need the digital age didactics to produce their own designs for teaching, learning and assessment. Particularly, student-teachers need the model to produce their own designs for teaching, learning and assessment.

Secondly, the results show that digital age didactics allow for the development of competencies to promote collaboration in learning, independent learning and problem-solving skills. Student-teachers need the involvement, collaboration and online activities to extend knowledge and skills in mathematics instruction.

Again, the results show that student-teachers can perform their own activities and come out with their own innovative ideas and problem-solving skills. Student-teachers should be given the opportunity to explore varied materials and online resources necessary for propelling the principles of assessment, in both formative and summative, and in all assessment for, assessment as and assessment of criteria learning.

13. References

Ali, C. A., & Davis, E. K. (2020). Consolidating Didactic Pedagogies in Mathematics Education in the Era of Covi19 Pandemic in Teaching Experiences, Pedagogy and Practice in Ghana. *A Conference paper presented at digiTAL2020--Digital 2020 Conference: a virtual international conference on teaching, assessment and learning in the digital age*, South Africa (virtual online).

Akayuure, P. (2021). Use of vclass in mathematics education delivery: The UEW experience. *OCCE 2021 Digital Transformation of Education and Learning Conference*, Tampere University, 17th to 20th August, 2021.

Cohen, L., Manion, L., & Morrison K. (2011). *Research methods in education. 7th edition*. New York: Routledge.

Goos, M. & Bennison, A. (2019). A zone theory analysis of identity formation in mathematics teacher educators. *Eleventh Congress of the European Society for Research in Mathematics Education*, Utrecht University, Feb 2019, Utrecht, Netherlands. hal-02422523.

Heath, C., Hindmarsh, J. & Luff, P. (2010). *Video in qualitative research: Analysing*

social interaction in everyday life. Los Angeles: SAGE.

Hegedus, S., Tapper, J., & Dalton, S. (2016). Exploring how teacher-related factors relate to student achievement in learning advanced algebra in technology-enhanced classrooms. *Journal of Mathematics Teacher Education, 19*(1), 7-32.

Hernández-Carranza, E.-E., Romero-Corella, S.-E., & Ramírez-Montoya, M.-S. (2015). Evaluation of Digital Didactic Skills in Massive Open Online Courses: a Contribution to the Latin American Movement. *Media Education Research Journal, 44*(22), 81-89.

Jackson, M. (2017). Integration of ICT in the Mathematics Classroom. *Journal of Initial Teacher Inquiry, 3*(1), 90-93.

Jahnke, I., Olsson, A., Norberg, A., & Norqvist, L. (2014). Digital Didactical Designs: Re- Imagining Designs for Teaching and Learning Using Media Tablets. *EUNIS-2014-paper-template.doc.*

Jahnke, I. & Norberg, A. (2013). Digital Didactics – Scaffolding a New Normality of Learning. In: *Open Education 2030 - contributions to the JRC-IPTS Call for Vision Papers, Part III: Higher Education*, pp. 129-134.

http://blogs.ec.europa.eu/openeducation2030/category/vision-papers/higher-education/

Jahnke, I., Norqvist, L., & Olsson, A (2013). Digital Didactical Designs in iPad- classrooms. *In: Proceedings of the European Conference of Technology-Enhanced Learning*, ECTEL 2013, Cyprus.

Kjellsdotter, K. (2020). *Didactical Considerations in the Digitalized Classroom*. Gothenburg University: Gothenburg Studies in Educational Sciences 448.

Lütge, C., & Merse, T. (2020). *Digital Teaching and Learning: Perspectives for English Language Education*. Narr Franckie: Germany, available at https://www.narr.de/digital-teaching-and-learning-perspectives-for-english-language-educa-18244/.

McLaughlin, C. (2018). *What is digital education?* The University of Edinburg: Russell Group. Available at https://www.ed.ac.uk/.

Ministry of Education (2020). *Mathematics Common Core Programme Curriculum (Basic 7 - 10)*. Accra: National Council for Curriculum and Assessment (NaCCA).

Perri, F. (2018). *Digital Didactics: An Introductory Training Course for Teachers*. ResearchGate, retrieved from https://www.researchgate.net/publication/323890180.

Ruthven, K. (2013). *Frameworks for analysing the expertise that underpins successful integration of digital technologies into everyday teaching practice.* Paper presented at the Annual Meeting of the American Educational Research Association, San Francisco, CA. https://www.educ.cam.ac.uk/people/staff/ruthven/RuthvenAERA13DivKpaper.pdf.

Valsiner, J. (1997). *Culture and the development of children's action: A theory of human development.* (2nd ed.) New York, NY: John Wiley & Sons.

Remote Parental Guidance in Occupational Therapy for Children with Learning Disabilities

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Abstract
Children with learning disabilities or having a late learning developmental curve are often excluded from normal learning activities in schools and societies, whereby the parents are stressed in helping their offspring to achieve their learning objectives. One rehabilitation support which has not gained much popularity among Mauritians is Occupational Therapy. This paper aims to explore the possibilities of providing parents with remote guidance of occupational therapy for their children with learning disabilities. The study was conducted during the second wave of lockdown of the Covid19 pandemic in Mauritius. The initial research objectives were to (i) assess parents during the remote occupational therapy intervention session for children with learning disabilities (ii) provide basic remote occupational therapy training to parents, and (iii) propose recommendations to improve remote intervention for children with learning disabilities. The research methodology was purely qualitative and conducted online through observations, session feedback forms of parents, and suggestions from the therapist for improvement. The significance of this study can be adapted for other therapies specifically speech and some aspects of psychological support. Moreover, initiatives for providing support to parents in such situations may contribute in boosting the productivity of parents facilitating the tasks of their school teachers and consequently to the wellbeing of these parents and children.
Keywords: Learning Disabilities, Occupational Therapy, Online Guidance, Knowledge Transfer.

1. Introduction
The World Federation of Occupational Therapists (WFOT, 2012) states that Occupational Therapy (OT) is a client-centered health profession aimed at the promotion of health and well-being through occupation, to enable people to participate in the daily activities under the supervision of Occupational Therapists in the occupations they want to, need to, or are expected to do, or by adjusting the occupation or the environment to better support their occupation. Early OT founders foresee OT progressing as a scholarly and practical profession (Gordon, 2009). Occupational performance accordingly denotes the ability of any age group to choose, organise, and perform well-defined and meaningful occupation satisfactorily for being autonomous and to appreciate life towards contributing to the social and economic fabric of a society (Armitt *et al.,* 2002). The model of Human Occupation elucidates that the person's difficulties resulting from environmental challenge need to be examined and adjusted (Kielhofner, 2008). Formerly, the therapist was the primary decision maker while parents attend their child's therapy passively (Bazyk, 1989). With time, family-centered practice in paediatric OT involves participation of parents, families and the child with special needs through engagement in occupation (Rosenbaum et *al.,* 1998), acknowledging parents to understand their children best, while the family forms part of the intervention process fundamentally to ease the child's development (Lawlor and Mattingly, 1998).

2. Background Study
2.1 Learning Disabilities Among Children
The United States Office of Education (USOE, 1977) regulations for defining and identifying Students with Learning Disabilities stipulate specific learning disability (SLD) as a disorder in one or more of the basic psychological processes related to the understanding, using language, spoken or written,

manifesting as an imperfect ability to listen, think, speak, read, write, spell, or to do mathematical calculations. SLD comprises perceptual handicaps, brain injury, minimal brain dysfunction, dyslexia and developmental aphasia and the children with learning difficulties exhibit disparate degrees of inappropriate behaviour which is indeed not compatible with learning in mainstream classes (Bender, 1985a, 1985b; Mckinney and Feagans, 1983, 1984; Thurlow et *al*., 1983).

Additionally, the Individuals with Disabilities Education Act (IDEA) re-amended through Public Law 114-95 by Congress, stipulates in the Every Student Succeeds Act (2015) "Disability is a natural part of the human experience and in no way diminishes the right of individuals to participate in or contribute to society. Improving educational results for children with disabilities is an essential element of our national policy of ensuring equality of opportunity, full participation, independent living, and economic self-sufficiency for individuals with disabilities". IDEA emphasises that student educational success depends much on a good family-professional partnership.

Nevertheless, Stone and La Greca (1990) pointed out that 28% of the SLD were in the rejected category and 26% in the neglected category of the low status sociometric categories, highlighting the importance of evaluating the social components of LD status with objectives towards social intervention strategies. Contrarily, rejected children are perceived as highly disruptive, aggressive and less cooperative, with behaviours considered to be more off task, aggressive and disruptive in the classroom (Coie *et al.*, 1982; Dodge *et al.,* 1982), consequently experiencing greater level of loneliness than normal children (Asher and Wheeler, 1985), while neglected children are viewed as shy and withdrawn, with social anxiety (La Greca et *al.*, 1988).

2.2 Parental Support

Cognisance, commitments, cause and convenience were identified as the 4C determinants of parental engagement in supporting their children remotely during their online bharatanatyam dance (Mauree-Narrainen and Chetti, 2020). In the context of OT, Piggot *et al.* (2002) confirmed that parents expressed a state of unreadiness initially to be involved in the therapy of their Child with learning Disability (CLDs) but with time developed a relationship with their child's therapist, based on trust and honesty, to achieve true collaboration. Similarly, Whyte and Hart (2003) proclaimed that family-centered interventions in a rehabilitation setting entail the active engagement of families. Mackean *et al.* (2005) stated that family-centered care influence parental role in their child's care based on true collaboration as a family-professional partnership. Each family preferences for collaboration is unique (Nijhuis *et al.,* 2007) considering that child behaviour problems require parents' ideas about treatment participation (Nock *et al.,* 2007).

The Family Centered Care model by Arango (2011) comprises of factors associated with parents' experiences of children, aged 0 to 5 years, with Cerebral Paralysis whereby physical and/or OT intervention is conducted in a rehabilitation setting, considering contextual, process and outcome aspects. Yet, Morgan & Tan (2011) shared that some parents have feelings of insufficiency and lack of self-assurance. Patient and family-centered care principles guide healthcare professionals towards basic principles of patient and family engagement and empowerment as an assurance to safe, effective and high-quality health care (Rosenbaum, 2011). Besides, Saha and Beach (2011) reveal that patients have a high level of confidence and trust in health practitioners who exercise patient-centered communication while King and Hoppe (2013) further state that such a strategy impact on increased satisfaction and compliance, self-efficacy, reduced malpractice claims and enhanced patient results.

Remarkably, the An and Palisano model (2012) integrates firstly, determination of mutually agreed-upon goals for intervention; secondly, shared responsibility with family in daily routines; thirdly,

implementation of the intervention through individualised intervention with family engagement and meeting family identified needs; and fourthly, evaluation of child and family outcomes based on successes, challenges, and changes, and goals achievements as illustrated in Figure 1 below.

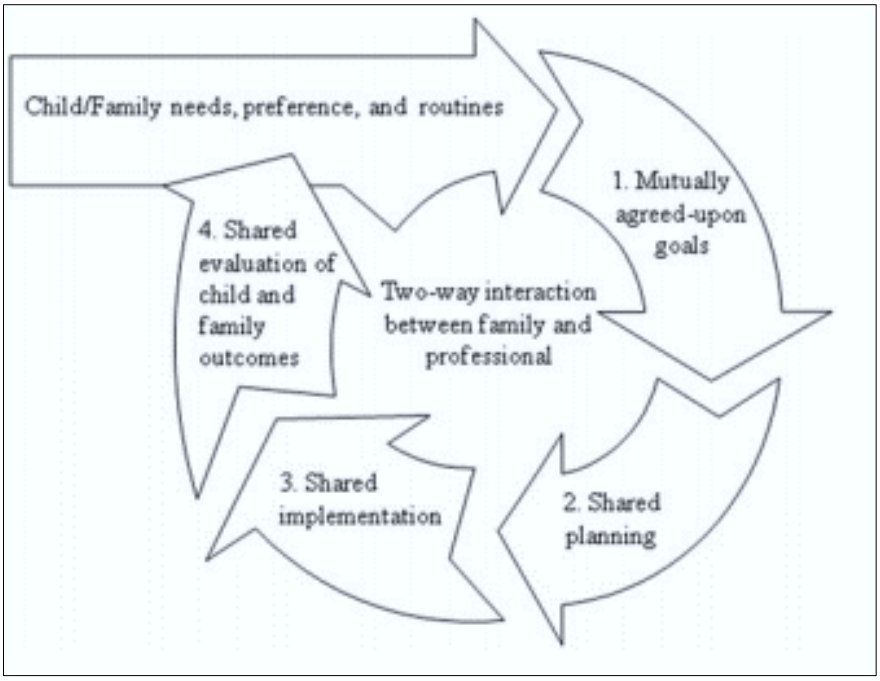

Figure 1: Model of Family - Professional Collaboration
(Source: An and Palisano, 2012)

2.3 E-Tools Adoption for Therapy

Telehealth programmes together with the instructional content through video, animation, and active learning tasks (Weingardt, 2004) have been used positively on patients. Ingersoll and Berger (2015) stated that parent–mediated intervention was approved as a critical component of effective autism involvement, proving the learning capability of parents in using evidence-based intervention techniques with fidelity in the enhancement of the child skills and behaviour. Expert clinicians have used email and teleconferencing mechanisms for intervention (Ingersoll and Wainer, 2013b), and implemented across health-related disciplines, disorders, and evidence-based treatment approaches (Gros et *al.,* 2013).

2.4 Knowledge Transfer in OT

Findings of Kolehmainen et *al.* (2010) suggested that supporting mothers actively to 'do things' for their child care and accessing services could be important for parents' satisfaction with therapists' caseload management. Knowledge management may back employees in the health care sector on how to knowledge creation, storage, transfer and implementation in their regular activities (Shahmoradi *et al.,* 2017), while researchers, academicians, fieldwork educators, clinical practice leaders and policy makers jointly need to be cognisant of knowledge transfer and translation concepts (Johnson, 2005), though knowledge creation and transfer substantiated to be a challenge (Levin, Cross and Abrams, 2002). Results related to parental direct participation in OT sessions indicate that under direct supervision in a medical environment results impact positively on cognitive, verbal, gross motor,

fine motor, social, and self-care abilities for children with developmental delay based on the family and children needs (Lin et *al.*, 2018). Consequently, parent participation in an OT plan contribute to better collaboration between parents and occupational therapists thereby improving parents' knowledge and skills in physiology, parenting, and information, all leading to better parental decision-making.

2.5 Research Context

In Mauritius, government bodies, NGOs and private sectors have created much awareness for Special Educational Needs (SEN) for CLDs. The SEN policy is aligned with Sustainable Goal Development 4, to 'ensure inclusive and equitable quality education and promote lifelong learning opportunity' by "Leaving no child behind" and its strategic Goal 8 is focused on Advocacy, Partnership and Empowerment whereby peers, teachers, parents and professionals are involved for Right Based Advocacy, shared responsibility and removal of attitudinal barriers. Some NGOs in Mauritius cater positively to the special educational provision by early intervention therapy support services with the intention to equip children having special needs with basic developmental skills namely physical, cognitive, communication, social, emotional, or adaptive development to address needs and build school willingness.

The private services of an occupational therapist help crucially in contributing to the daily quality lifestyle of some families having CLDs. Generally, when children have their face-to-face (F2F) private intervention OT sessions (IOTS), on average once a week, parents spare some time to attend the sessions passively. Generally, the onus of OT falls on the shoulders of the OTs. Yet, there has been a shift of this responsibility to parents in the advent of the Covid19 pandemic. During the first lockdown of the Covid19 pandemic in March 2020 in Mauritius, CLDs experienced much regression in their learning process. The entire three months during that dark period revealed quite a negative impact whereby parents themselves conducted the IOTS with their children. The home programme given by OTs could unfortunately not be implemented fully due to lack of time of working parents. The core problem was parental disengagement due to lack of knowledge and skills to deal with their CLDs. Once the first lockdown was removed in May 2020, children could benefit again their home IOTS. Yet, when the 2nd wave of pandemic struck with another confinement in March 2021, parents were eager to take up the challenge ambitiously to support their CLDs remotely under the supervision of an occupational therapist.

Parents of CLDs are not equipped with the knowledge and skills to carry OT interventions in the absence of a therapist. It was observed by the researchers in this study during the first lockdown in March 2020 that CLDs were seen to have a regression in their objectives set due to not having consistent OT sessions. This could have been avoided if parents could carry out the OT sessions with their children following the guidance of an occupational therapist in case the latter is not physically present. So far, research in OT in Mauritius is very limited as this profession lacks much visibility and its importance in rehabilitation. The aim of this study was to initiate remote sessions for continuity of interventions for CLDs during the 2nd wave of the lockdown period to avoid learning regressions. The main objectives were set to (i) assess the difficulties faced by parents in the absence of the OT for intervention (ii) provide guidance as needed to support the parents (iii) develop suitable strategies to involve parents effectively during remote OT sessions towards an improved learning and developmental performance (iv) come up with recommendations for further implementations.

3. Research Methodology

This study aimed at determining the possibility of having IOTS with CLDs during the second lockdown period of the Covid19 pandemic undertaken from 8th March 2021 to 7th August 2021 (5 months). Participants were 12 CLDS excluding 12 mothers, 6 fathers and an experienced OT. The parental guidance and assessments were done on average twice weekly during the IOTS via WhatsApp. Each session comprised of 45 mins to 1 hour. Parents were given some additional intervention tasks to do

on their own without OT assistance during their free time. The researchers opted for a qualitative method as experiential research to allow capture insight through remote observations, opinions and views of parents, and OT and children's behaviour, based on the following criteria:

(i) Children aged from 3 years to 10 years old
(ii) Children having a learning disability
(iii) Children who were already following F2F OT sessions 6 months minimum before the pandemic.

The OT had a batch of 12 children who were all participants in this study. Parents were offered free remote sessions via WhatsApp supported and guided by the OT to in turn sustain the intervention sessions of their children. The strategies developed to meet the research objectives were:

Strategy 1: Notifications sent to Parents for OT Sessions via WhatsApp
In this strategy, the parents were invited for OT sessions at a specific time during the day for a one-hour duration. During the first few sessions, only mothers were interested to carry out the sessions, and even though exhausted with household chores, professional and family commitments, they maintained zealously the sessions. So, all goals set for the children were not met efficiently. Accordingly, strategy 2 was then formulated by inviting the fathers to join for IOTS.

Strategy 2: Notifications sent to Fathers for OT Sessions via WhatsApp
In this strategy, only fathers were invited for the OT session who consequently realised the real situation faced by their wives with their CLDs. Assisted by their wives, they were the ones who had the lead role in helping their little ones, which ultimately changed attitudes positively with regard to IOTS.

Strategy 3: Notifications sent to Both Parents for OT Sessions via WhatsApp
Strategy 3 involved both parents for the OT session. Some families could not be involved fully in this strategy due to other family and professional commitments. Nevertheless, it absolutely paved the way for team building between wife and husband.

Strategy 4: Combination of Online and Face to Face Sessions
Once lockdown was removed during the first week of May 2021, the Occupational Therapist in this study continued the OT session on a blended mode, using both WhatsApp and F2F sessions. One family preferred to go fully online for the IOTS during the whole 5 months.

Strategy 5: Evaluation of Child Progress under Mentorship of Parents
This strategy encompassed the evaluation phase where both parents were emailed the evaluation form for the session in which they participated.

Criteria for Parental Assessment
Since each child is unique, the objectives set and the intervention plans were different for each child. A tailor-made assessment form was sent to each parent based on the objectives they focused on during the IOTS. The first section of the assessment form was on the different skills to be rated and their progress status. The second section of the assessment form was based on their observations and difficulties encountered with their children during the OT session. Activities and materials were prepared as an OT kit and sent for their remote sessions. Once objectives were attained, activities were upgraded by the OT, considering the availability of materials at home during lockdown.

4. Findings, Analysis and Discussions

As a note of observation, Mauritius still operates under the patriarchal system. Yet, the mother/wife assumes the responsibility of looking after the household needs, upbringing and education of the children and attending F2F IOTS conducted in the home environment for the CLDs. Positively, the Covid19 pandemic has led to a constructive paradigm shift where fathers had to step in. The detailed findings are elaborated below in a subsection outlining parents' capabilities, occupational therapist capabilities, children's progress and other support systems.

4.1 Parents' Capabilities

4.1.1 Parents Profile

Out of the 12 families involved, 5 families, both mother and father were IT proficient. It is worth noting that 6 out of 12 mothers were digital literate. Only 6 out of 12 fathers positively contributed to the IOTS. Some parents were working from home while some others had to attend physically their office premises. With regard to consent approval for conducting remote IOTS, all 24 parents eagerly accepted this new approach.

Table 1: Parents' Professional Profile

	Dad's Profession	Dad's IT Literacy Aptitude	Mum's Profession	Mum's IT Literacy Aptitude
Parent 1	Stone Crusher	×	Maid	×
Parent 2	Mechanics	×	Housewife	×
Parent 3	Educator	✓	Educator	✓
Parent 4	Analyst	✓	Educator	✓
Parent 5	Customer Service Officer	×	Accountant	✓
Parent 6	IT Officer	✓	Educator	✓
Parent 7	Supervisor	×	Clerk	×
Parent 8	Police Officer	✓	Educator	✓
Parent 9	Gym Instructor	×	Nursing Officer	×
Parent 10	Shopkeeper	×	Housewife	×
Parent 11	Sales Consultant	×	Housewife	×
Parent 12	BPO Team Leader	✓	Operations Manager in Manufacturing	✓

4.1.2 Device Used

All parents used WhatsApp via smart phones for the IOTS. After 2 weeks, the research team proposed the transition to google classroom platform for a better monitoring of each IOTS for CLDS. Out of the 24 parents, only 6 parents were agreeable. The others preferred WhatsApp calls only. This attitude was due to the fact that some lacked much basic digital literacy skills, others did not have the tools needed, while the rest faced internet connection issues. On this basis, the IOTS were conducted remotely via WhatsApp only for all CLDs.

4.1.3 Parents' Commitment

All mothers were seen to be more involved physically, mentally emotionally and psychologically than the fathers, who had to be invited for remote IOTS. After 4 remote sessions, it was observed that 6 out of 12 fathers had a readiness to participate in the IOTS of CLDs and dedicated a free time slot for this activity.

4.1.4 Parents' Knowledge Acquisition

Mothers understood passively the basic knowledge of the procedural activities since they attended F2F OT sessions before lockdown. It was found that during the remote IOTS the parents were more involved. They could better ask questions of what, why, how, when where with regard to the OT being provided. As a result, both parents could improve their knowledge to deal better with their CLDs, denoted in Tables 2 and 3 in Appendix 1 for references.

4.1.5 Parents' Understanding

Previously, most parents were unaware of the importance of IOTS continuity program with the children. Their mindset changed considerably with the regression in their children's learning curves during the first lockdown in March 2020. Moreover, with the change in school calendar in Mauritius, parents were reluctant for their offsprings to remain idle waiting for school resumption.

4.1.6 Parents' Difficulties

Parental engagement for IOTS was much better during the March 2021 lockdown. Fully engaged parents requested for homework to improve areas where their children were facing challenges, even for the children who could not be managed easily. Yet, parents faced some areas of difficulties during their remote IOTS. The Areas of Difficulties for the 6 fathers had been mainly 'Knowledge on Performance Areas', 'Understanding Symptoms and Difficulties associated with a Specific Disability', and 'Developing Creative Skills' as depicted in Table 4 in Appendix 2. As for the 12 fully engaged mothers, 'Knowledge on Performance Areas', Understanding Symptoms and Difficulties associated with a Specific Disability', 'Handling child's Behaviour and Tantrums', Adopting a more Firm Attitude' and 'Organisation of Activities during Sessions' were the major areas of difficulties they experienced, as shown in Table 5 in Appendix 2.

4.1.7 Parents' Contribution

Parents used their own creative and innovative skills to get their young learners' attention. Additionally, both parents of one young learner shared their regular observation notes of their child's behaviour and attitudes with the OT, as discussed by Nock *et al., (*2007). Parents could allocate time to understand their children's abilities better. They started taking initiatives on their own even after sessions in order to have IOTS continuity at home with their CLDs. Parents understood the purpose behind objectives settings and how to work towards fulfilling them. All mothers discussed their children's behaviour with the OT, based on their daily observations, while 6 out of 12 fathers also mentioned their remarks on their children but not on a daily basis. This insight pointed out that parents could improve their observational skills significantly. Furthermore, the OT encouraged the parents to conduct their own IOTS without her guidance.

4.1.8 Parents' Emotional Quotient

The lockdown was indeed a stressful situation for parents to manage their home, family, children and work. The mental and emotional wellbeing of parents determine the quality of their participation and delivering during the remote IOTS. It was observed that majority of parents had some level of negative stress for which the therapist implemented some de-rolling sessions conducted for 7 parents who were very strained. The term 'de-rolling' refer to a set of activities that support the subjects of therapy in 'disrobing' themselves from their characters (Harrington, 2017). Hence, this technique enabled parents to take their various roles off their daily lives and focus on themselves. The OT also provided

counselling with the objective to improve their living conditions. These de-rolling sessions contribute added on positively towards goal achievements of the CLDs under observation in this investigation.

4.1.9 Parents' Satisfaction

All 24 parents attending the remote IOTS happily confirmed significantly their satisfaction in collaborating with the therapist. They understood the importance of having IOTS for the physical, mental, emotional, and educational developmental progress of their children. They also admit that their knowledge, skills and talents have expanded towards a better understanding of their CLDs.

4.1.10 Parents' Skills Development

From the regular remote observations via WhatsApp, all parents needed training and guidance: (i) to handle their CLDs, (ii) for goal formulation and (iii) to improve their basic OT and other skills as shown in Tables 6 and 7 in Appendix 3 regarding the various skill sets developed by mothers and fathers.

4.1.11 Parents' Personality Trait

Interestingly, the online guidance for OT intervention contributed to the development of some personality traits, namely, patience, confidence, motivation, and to encourage the parents to act as coach, as exemplified in Tables 8 and 9 in Appendix 4.

4.2 Occupational Therapist Capabilities

4.2.1 OT Profile

The occupational therapist holds a BSc (Hons) in Occupational Therapy and MBA together with 6 years of hands-on practice with patients with disabilities, including children. All her remote IOTS during the lockdown were free. Her aim was to ensure that her young clients continue achieving their goals during confinement. She aligned her training with the national syllabus of Education and Learning milestones.

4.2.2 OT Support

During the first lockdown, 3 out of 12 families requested the OT for advice. Upon resumption of her F2F sessions, the therapist noted a big regression and restarted all objectives set previously as developmental milestones. Conversely, after the second lockdown was removed, the OT picked up easily new learning and developmental milestones since parents were involved during the remote IOTS.

4.2.3 Knowledge Transfer

The therapist ensured that the most appropriate knowledge was transferred to the 12 mothers and 6 fathers. Each child had his/her own syllabus and sets of tasks to achieve during the OT sessions. At the end of each remote session, the OT explained the 'know-what' and 'know-why' behind each activity to each parent. Explanations with regard to brain functioning, eye-hand coordination and special needs' requirements were transferred to the parents for them to understand better the special biological aspects of their CLDs (Refer to Tables 2 and 3 in Appendix 1).

4.2.4 Skills Transfer

Basic OT skills taught to the parents in the areas related to Activities of Daily Living (ADLs) so that their CLDs can become autonomous, improve their language and speech, be able play and be involved in social participation (Refer the Tables 6 and 7 in Appendix 3).

4.2.5 Feedback Mechanism

Each remote IOTS concluded with a feedback hearing from the therapist to parents who were engaged. Feedback helped them to build on their patience, enthusiasm, determination, team building among the father and mother, problem solving, and interpersonal skills.

4.3 Child Progress

4.3.1 Children's Profiles

The children chosen for the study were all young learners with a learning disability. The OT made emphasis on all the three Occupational Performance Areas: (1) Self Care, (2) Productivity and (3) Play and Leisure. After conducting the Canadian Occupational Performance Measure (COPM) Assessment with the parents and an observational session with the children, the OT had already set down all the objectives which needed to be achieved before the pandemic. The objectives set were not only in the academic area but all the three areas depending on the priority set by the parents and based on the developmental milestones of the child. The skills worked on were: Self Dressing, feeding, toileting, personal hygiene, grooming skills, fine motor skills, visual perceptual skills, visual motor integration, gross motor skills, bilateral coordination, sensory processing, social skills, behaviour management and communication skills. Based on the objectives set, some activities were designed for the children by the OT while other activities were left to the parents to innovate. Parents were taught how to use cheap and available materials to create new activities. The activities were made attractive in order to engage the children more and to make it of their interest depending on their preferred cartoons or likes.

4.3.2 Overall Remarks of Child's Progress

The therapist noticed progress in all the children. Although parents know their CLDs better than the therapist, they requested guidance from the therapist to learn more about their CLDs in order to improve their observational skills. All the children had improvements in the different performance areas: 1) Self Care, (2) Productivity and (3) Play and Leisure. Improvements were noted in the following abilities: self-dress, feeding, toileting, personal hygiene, grooming skills, fine motor skills, visual perceptual skills, visual motor integration, gross motor skills, bilateral coordination, sensory processing, social skills, behaviour management and communication skills. It is confirmed that motivated parents support their CLDs to improve at a quicker pace.

5. Other Support Systems

5.1.1 Home Modification

The home environment of the 12 CLDs had to be modified accordingly to their needs during the remote IOTS.

5.1.2 Assistive Devices (AD)

Existing physical toys and educational tools available at home, namely, puzzles, white boards, slates and colouring shapes were used to support the CLDS. Some other cheap available materials from the kitchen, household tools and relevant Youtube channels for speech and learning were also optimised as ADs and as assistive technological tools.

5.1.3 Relative Support

Close relatives form part of the support system for a continuous learning for these children. In one case, the grandmother and grandfather were involved in the parental guidance process.

The above findings have thrown light towards a holistic approach as shown in Figure 2 below of an OT support system for inclusive education for children with LD. The external environment includes home

and classroom modifications, ADs, teacher training, F2F/online intervention and parental training as the 1-Tier environmental factors influencing the CLDs developmental support.

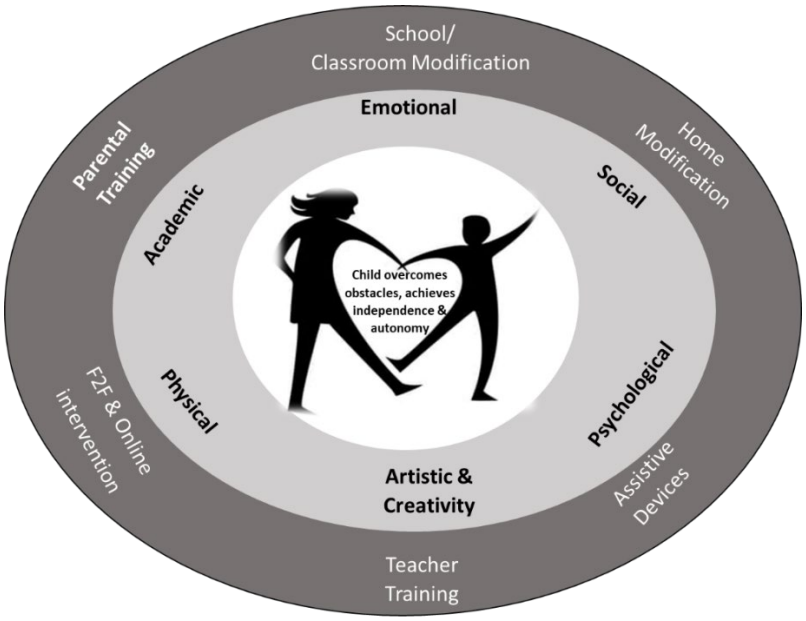

Figure 2: Holistic Approach of Occupational Therapy Support System for Inclusive Education for Children with Learning Difficulties (Authors' Own Compilation)

These external environmental factors (EEF) impact directly on the 2-Tier as the Well Being factors namely academic, physical, emotional, social, psychological, artistic and creative dimensions of the child, supporting him/her to overcome obstacles in life, and to achieve independence and autonomy. In addition, successful outcomes of any OT initiatives for a client also depend on other extended support systems such as involvement of grandparents, as we have seen in one family in this investigation, and also on school teachers. These two additional relational actors can be given access to their guardians' dashboard to view their CLDS progress and be able to input their behaviours and remarks. The ability to tap into such extended support systems allows the creation of different layers of bonding between the parents, mother and child, father and child, grandparents and child, nanny and child, and school teacher and child, and point solely towards the whole well-being and development of the child with a learning disability, avoiding thus the risks of social and educational exclusion.

6. Conclusions, Recommendations and Future Work

6.1 Conclusions

This study assessed parents in their own IOTS for their CLDs via WhatsApp by an experienced occupational therapist. Prior to the second lockdown of the Covid19 pandemic, parents were passive in the F2F sessions as also seen by Bazyk (1989). During the confinement in March 2021, lasting seven weeks, parents were provided with some basic OT intervention trainings. Overall, the 12 mothers and 6 fathers benefitted from the training and guidance provided by therapist towards the child's development, as pointed out by Lawlor and Mattingly (1998). The usage of WhatApp in this study as a teleconferencing medium as mentioned by Ingersoll and Wainer (2013b) supported towards positive results in rehabilitation as stated by Gros et *al.* (2013). The study also supported parents in identifying their children's level of difficulties during their ADLs, communication through speech, play and their

social participation. Five key capabilities of the OT appreciated were support provided, knowledge transferred, and skills taught. Personality traits and feedback mechanism form part of the initial guidance strategy for parents whose satisfaction with the professional services of the therapist contribute to confidence and trust (Saha and Beach, 2011). Moreover, parents' commitment represents an important determinant in remote IOTS and the same was also identified in the study of engaging young learners in learning bharatanatyam (Mauree-Narrainen and Chetti, 2020).

As for the CLDs, with the remote support of the OT and physical support of the parents, most objectives were achieved with remarks that some children were upgraded with enhanced results as mentioned by King and Hoppe (2013). The holistic approach of the OT support system for inclusive education for CLDs that emerged from this study depicts a model encompassing environmental factors, namely, academic, physical, emotional, social, psychological, artistic and creative dimensions of the CLDS to face life challenges, as well as parental/teacher training, school/home modifications, assistive devices, F2F and online interventions. The findings can be further adapted for speech, and other psychological support not only for children in this segment but also for all categories of patients.

6.2 Recommendations

A set of recommendations have been worked out in the field of OT for pediatric and CLDs. With the pandemic still spreading, use of internet-based technological tools would accelerate OT guidance for the parents. A web-based system proposed as e-Intervention Occupational Therapy Support System (e-IOTS) would unquestionably give positive results in the online OT initiative towards better knowledge transfer, experiences and techniques. However, as the matter stands, an immediate requirement is to train the majority of parents in basic digital literacy skills and tools so that they can use the proposed e-IOTS. Notably, the existing Universal ICT Education Programme (UIEP) offered by the National Computer Board in Mauritius intends to benchmark the digital literacy/proficiency in Mauritius. Hence, parents are encouraged to follow this course to improve their digital proficiency. Once this first goal has been achieved by the parents, this paves the way for a tailor-made Occupational Therapy for Parents' training programme to be hosted online on the e-IOTS, a second strategy to facilitate parents in their acquisition of basic OT knowledge and skills. Thirdly, an online regular assessment strategy for parents by the OT support in evaluating the progress of the parents in their OT mission towards their CLDs. Fourthly, the proposed e-IOTS to include an online class for CLDs. Parents can thus log in for live OT sessions with documented materials for their children. Integration of an online diary for the recording of children's behaviors could be integrated with the objective to allow the OT to view the behavior records so that he/she can further counsel on behaviours' improvement. Engaging the fathers in IOTS (both Online & F2F) is recommended highly so that they are involved continuously in the contribution of the learning development of their CLDS. From the above knowledge, skills and personality traits acquired by the parents during online OT sessions discussed in section 4.1.11, a model is proposed below. The proposed knowledge and skills transfer mechanism require parents to have appropriate digital literacy skills which will facilitate their adopting a proposed e-Intervention Occupational Therapy Support System (e-IOTS).

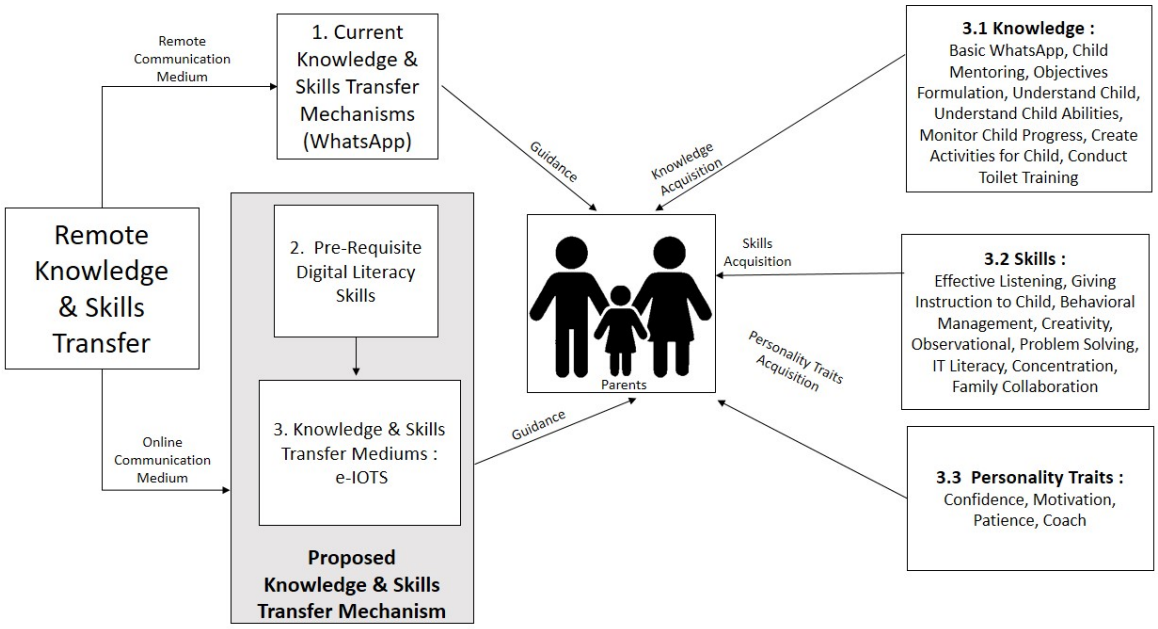

Figure : OT Parental Knowledge and Skills Transfer

Figure 3: OT Parental Knowledge and Skills Transfer
(Authors' Own Compilation)

6.3 Future Work

The investigation has kindled a further study on father engagement in this holistic approach of OT support system for inclusive education for CLDs. Likewise, creative ideas by parents can be shared with other parents approved by the therapist as a collaborative activity among parents. Next, the e-IOTS can add some mechanisms for the Community of Practice (CoP) of other Occupational Therapists at national and international levels as guest speakers to share their knowledge and experiences. The fact that OT is involved with the different segments of the population, many low cost objects can also be devised and low costs activities may be innovated by OTs and even parents for needy families undertaking IOTS. The tacit knowledge transferred could be in the form of video, audio or explicit documentations, turning this into another drive towards a robust online knowledge exchange system accessible to all stakeholders. The OTs are invited to look for ways and means to develop creative online de-rolling sessions to sustain better parental guidance, engagement and collaboration on remote IOTS for CLDS. In addition, advanced course in developing skills on different performance areas of paediatric OT to train parents on specific objectives and provide them with knowledge on the same. Correspondingly, there is some margin to add a quantitative approach in this study and also scaling up the experiment in the future. In a nutshell, with a customised lifestyle, parents having the mental and emotional power are equipped better in grooming their CLDs who are foreseen to contribute becoming future working citizens, contributing better thus to a better productive society.

7. References

Policy Framework and Strategic Document SEN, (2017). Inclusive Education for Children and Youth with Special Needs in Mauritius: Concept to Reality. https://education.govmu.org/Documents/educationsector/Documents/Special%20Education%20Needs/SEN_Strategy_2017_Final.pdf

Association of Disability Service Providers, (2021). Holistic Education. (http://adspmauritius.com/what-we-do/#holistic)

An, M.; Palisano R.J. (2013). Family–professional collaboration in pediatric rehabilitation: a practice model. Disability and Rehabilitation International and Multidisciplinary Journal.

Arango, P. (2011) Family-centered care. Academic Pediatrics, 11, 97–99

Armitt, B.M.; Bruggen, J.V.; Daniel, R.; Ghyselen, L.; Green, S.; Sandquist, J. and Sixsmith, A. (2002). The Provision of Education and Training for Health Care Professionals through the Medium of the Internet. Sheffield Hallam University Research Archive. Vol. 19, No. 4. pp. 135-144.

Asher, S.R., & Wheeler, V.A. (1985). Children's loneliness: A comparison of rejected and neglected peer status. Journal of Consulting and Clinical Psychology, 53, 500-505

Bazyk, S. (1989). Changes in attitudes and beliefs regarding parent participation and home programs: An update. American Journal of Occupational Therapy, 43, 723–728.

Bazyk, S.; Demirjian, L.; LaGuardia, T.; Thompson-Repas,K.; Conway, C. and Michaud, P. (2015), 'Building Capacity of Occupational Therapy Practitioners to Address the Mental Health Needs of Children and Youth: A Mixed-Methods Study of Knowledge Translation,' The American Journal Occupational Therapy. Vol. 96, No. 6. pp 1-12.

Bender, W.N. (1985a). Differences between learning disabled and non-learning disabled children in temperament and behavior. Learning Disability Quarterly, 8, 11-18.

Bender, W.N. (1985b). Differential diagnoses based on the task-related behavior of learning disabled and low-achieving adolescents. Learning Disability Quarterly, 8, 261-266.

Coie, J., Dodge, K., & Coppotelli, H. (1982). Dimensions and types of social status: A crossage perspective. Developmental Psychology, 18, 557-570.

Coie, J.D., & Kupersmidt, J.B. (1983). A behavioral analysis of emerging social status in boys' groups. Child Development, 54, 1400-1416

Gordon, D. (2009), "The history of occupational therapy", in Crepeau, E.B., Cohn, E.S. and Boyt Schell, B.A. (Eds), Willard and Spackman's Occupational Therapy, Vol. 11, Lippincott, Williams & Wilkins, Philadelphia, PA, pp. 202-215.

Gros, D. F., Morland, L. A., Greene, C. J., Acierno, R., Strachan, M., Egede, L. E., et al. (2013). Delivery of evidence-based psychotherapy via video telehealth. Journal of Psychopathology and Behavioral Assessment, 35, 506–521. doi:10.1007/s10862-013- 9363-4.

Ingersoll, B., & Schreibman, L. (2006). Teaching reciprocal imitation skills to young children with autism using a naturalistic behavioral approach: Effects on language, pretend play, and joint attention. Journal of Autism and Developmental Disorders, 36, 487–505. doi:10.1007/s10803-006-0089-y.

Ingersoll, B., & Wainer, A. (2013a). Initial efficacy of Project Impact: A parent-mediated social communication intervention for young children with ASD. Journal of Autism and Developmental Disorders, 43, 2943–2952.

Ingersoll, B., & Wainer, A. (2013b). Using distance learning technology to increase dissemination of evidence-based practice in ASD. In K. Boser, M. Goodman, & S. Wayland (Eds.), Technology

tools for students with autism: Innovations that enhance independence and learning. Baltimore, MD: Brookes Publishing.

Ingersoll, B., & Berger, N. (2015). Parent Engagement With a Telehealth-Based Parent-Mediated Intervention Program for Children With Autism Spectrum Disorders: Predictors of Program Use and Parent Outcomes. Journal of Medical Internet Research. JMIR Publications. Advancing Digital Health and Open Science, Vol 17, No. 10

Johnson, L.S. (2005), 'From Knowledge transfer to knowledge translation: Applying research to practice', Occupational Therapy Now. Vol. 7, No. 4. Pp 11-13.

Kielhofner G. (2008). Model of Human Occupation: Theory and application (4th ed.). Baltimore, MD: Lippincott Williams & Wilkins

King, A., & Hoppe, R. B. (2013). "Best practice" for patient-centered communication: a narrative review. Journal of Graduate Medical Education, 5(3), 385-393.

Kolehmainen, N., Duncan, E., McKee, L., Francis, J. (2010). Mothers' Perceptions of Their Children's Occupational Therapy Processes: A Qualitative Interview Study. British Journal of Occupational Therapy 73(5):192-199, DOI:10.4276/030802210X12734991664101

La Greca, A.M., Dandes, S.K., Wick, P., Shaw, K., & Stone, W.L. (1988). Development of the Social Anxiety Scale for Children: Reliability and concurrent validity. Journal of Clinical Child Psychology, 17, 84-91

Lawlor, M. & Mattingly, C. (1998). The complexities embedded in family-centered care. American Journal of Occupational Therapy, 52, 259–267

Levin, D.Z., Cross, R., Abrams L.C. (2002). The strength of weak ties you can trust: The mediating role of trust in effective knowledge transfer. Academy of Management Proceedings 2002, EBSCO Publishing

Lin, C.L, Lin C.K., Yu J.J. (2018). The effectiveness of parent participation in occupational therapy for children with developmental delay. Neuropsychiatric Disease and Treatment 2018:14, Dovepress

MacKean, G. L., Thurston, W. E. & Scott, C. M. (2005). Bridging the divide between families and health professionals' perspectives on family-centred care. Health Expectations: An International Journal of Public Participation in Health Care and Health Policy, 8, 74–85

Mauree-Narrainen, D., Chetti R. (2020). Young Learners' Engagement in Learning Bharatanatyam Online during Covid19 Pandemic. Conference paper presented at digiTAL2020--Digital 2020 Conference: a virtual international conference on teaching, assessment and learning in the digital age, South Africa (virtual).

Nijhuis, B. J., Reinders-Messelink, H. A., de Blecourt, A. C., Hitters, W. M., Groothoff, J.W., Nakken, H. & Postema, K. (2007). Family-centred care in family-specific teams. Clinical Rehabilitation, 21, 660–671.

Nock, M. K., Ferriter, C. & Holmberg, E. (2007) Parent beliefs about treatment credibility and effectiveness: assessment and relation to subsequent treatment participation. Journal of Child and Family Studies, 16, 27–38

Piggot, J., Paterson, J. & Hocking, C. (2002) Participation in home therapy programs for children with cerebral palsy: a compelling challenge. Qualitative Health Research, 12, 1112–1129

Rosenbaum, P., King, S., Law, M., King, G. & Evans, J. (1998). Family-centred service: A conceptual framework and research review. Physical and Occupational Therapy in Pediatrics, 18, 1–20

Rosenbaum, P. (2011). Family-centred research: what does it mean and can we do it? Developmental Medicine & Child Neurology, 53(2), 99-100.

Shahmoradi, L., Safadari R., Jimma W. (2017). Knowledge Management Implementation and the Tools Utilized in Healthcare for Evidence-Based Decision Making: A Systematic Review, Ethiopian Journal of Health Sciences 27(5):541-558, DOI: 10.4314/ejhs.v27i5.13

Stone W.L., La Greca A.M. (1990). The Social Status of Children with Learning Disabilities: A Reexamination, Journal of Learning Disabilities, Volume 23, Number I.

McKinney, J.D., & Feagans, L. (1984). Adaptive classroom behavior of learning disabled students. Journal of Learning Disabilities, 16, 360-367.

Saha, S., & Beach, M. C. (2011). The impact of patient-centered communication on patients' decision making and evaluations of physicians: a randomized study using video vignettes. Patient Education Counseling, 84(3), 386-392.

Thurlow, M., Graden, J., Greener, J., & Ysseldyke, J. (1983). LD and non-LD students' opportunities to learn. Learning Disability Quarterly, 6, 172-183.

United States Office of Education. (1977), Definition and Criteria for defining students as learning disabled. Federal Register, 42:250, p.65830. Washington, DC: U.S. Government Printing Office.

Weingardt, K. R. (2004). The role of instructional design and technology in the dissemination of empirically supported, manual-based therapies. Clinical Psychology: Science and Practice, 11, 313–331. doi:10.1093/clipsy/bph087.

Whyte, J. & Hart, T. (2003). It's more than a black box; it's a Russian doll: defining rehabilitation treatments. American Journal of Physical Medicine & Rehabilitation/Association of Academic Physiatrists, 82, 639–652.

Towards a Framework for the Problematisation of Graduate Supervision of Computing Students in an Open Distance e-Learning (ODeL) Environment

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Abstract
This paper proposes a problematisation framework for scientific knowledge in the area of supervision of graduate Computing students (i.e., masters and doctoral students in Computer Science, Information Technology, and Information Systems) in an Open Distance e-Learning (ODeL) environment. The proposed problematisation framework is a three-tiered construct. The top tier questions epistemological, ontological, and methodological aspects of knowledge generation in the area under research. A second-tier questions schools of thought and metaphors that guide knowledge in the research area. A third-tier questions theories, practices, activities, tools, and text in the research area. The framework thus allows for the problematisation of a range of issues at the intersection between ODeL, graduate supervision and Computing research ranging from the assumptions and paradigms that inform knowledge in this research area to the practical aspects of day-to-day supervision of graduate students. The proposed problematisation framework holds significant benefits for baseline studies, as it allows not only for the identification of research gaps, but a problematisation in terms of underlying assumptions and conceptualisations, thus creating potential for the identification of strong research questions and research areas. Future work may include a validation of the framework and commencing projects in under-researched areas that emerge from the use of the problematisation framework.
Keywords: Computing, Graduate supervision, Open Distance e-Learning, Problematisation framework.

1. Introduction

Literature on postgraduate supervision indicates some universal challenges faced across disciplines. Examples of these are the relatively low numbers of graduate students who are actually full-time on-campus and the diversity of study and research habits among groups of graduate students (Pearson, 1999). Furthermore, the academic context at universities is rapidly changing and this impacts in various ways on academics (Bitzer & Albertyn, 2011), for instance in terms of the relationship between tuition and research duties (Lee & Green, 1995), and ever-expanding processes and requirements around university governance (Halse & Malfroy, 2010). The increasing numbers of graduate students also increase pressure on the system (Bitzer & Albertyn, 2011).

In this paper we formalise and significantly expand an idea presented in a talk at an Open Distance e-Learning (ODeL) conference for Science, Engineering and Technology subjects organised by the University of South Africa (UNISA) (Van der Poll & Lotriet, 2013). The original talk examined issues around the supervision of masters and doctoral students in Computing disciplines in an Open-Distance-e-Learning (ODeL) environment at an exploratory level. In this paper the focus is on proposing a framework that can be used to systematically problematise this area of research.

The graduate supervision of masters and doctoral students in Computing brings about a unique set of challenges. A first challenge relates to the diversity of the graduate student population in Computing. Computing students embody a mix of Computer Science (CS), Information Technology (IT) and Information Systems (IS) students. These disciplines are often grouped together at tertiary level – in the case of the authors' institution as a School of Computing. Other South African examples include

the School of IT at the University of Cape Town and the overarching South African body, the South African Institute of Computer Scientists, and Information Technologists (SAICSIT). For discussion of an example of a department with both CS and IS graduate students see Calitz *et al*. (2016). The grouping represents on the one end of the spectrum a mix of technical, often discrete mathematical, and formal logic contents for Computer Science students, technical and computer tool-focused contents for IT students, and on the other side of the spectrum a mix of technical, business and more qualitative aspects for Information Systems students. Yet, the divisions between the disciplines are not cut-and-dried (Baskerville, 2008) and therefore, graduate students in these disciplines are often touching on the intersections between the disciplines. For instance, CS students often embed IS aspects in their research while IS students in turn could use aspects of CS or IT in their research.

Distance education (and specifically online education) is rapidly growing at all levels of education, including graduate studies (De Oliveira *et al.*, 2018). However, online supervision of graduate students incurs additional complexities and challenges to both supervisors and students (Erichsen *et al.*, 2014). For this reason, various aspects of graduate supervision in an online environment have received considerable attention from researchers – some examples are Erichsen *et al*. (2014) *op. cit.*, Rodger & Brown (2020) and Ramukumba (2015). The field of online graduate supervision in Computing has also received some attention among researchers such as Van Biljon *et al*. (2020) and Kassegne, (2006).

This paper is written as part of an on-going research project on graduate supervision of Computing students in an ODeL environment. Both authors are supervisors of graduate Computing students at an ODeL institution and therefore have an interest in understanding the current state of knowledge and challenges in the area represented by the intersection of the circles in Figure 1.

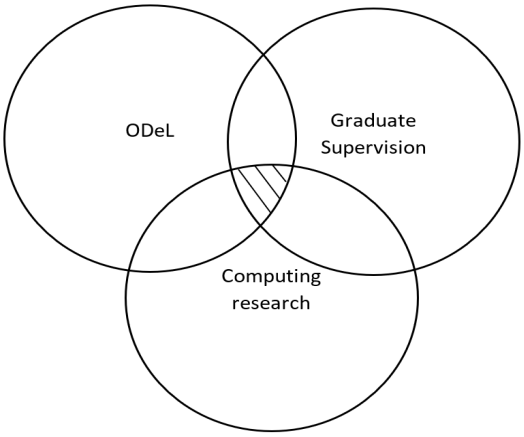

Figure 2: Research focus

As a first phase of the research the authors are interested in establishing a systematic view of the existing state of knowledge in the research focus area, to better understand existing knowledge, challenges, and opportunities for further research. Consequently, this paper proposes a structure for the problematisation of existing knowledge in the research focus area. Although the researchers are South African, the proposed problematisation structure is generic in nature and the intention is therefore that its application would be for general application to knowledge at the intersection of the knowledge areas of ODeL, graduate supervision and Computing.

Many problematisation frameworks are informed by the seminal work of philosophers such as Foucault (Frederiksen et al., 2015) or Kuhn (Morgan, 1980). We propose the use of a three-tiered construct proposed by Morgan (1980, op. cit.) based on Kuhnian principles to develop our problem-

solving framework. This allows problematisation of both ideologies that inform knowledge, down to the practical aspects of day-to-day supervision of graduate students.

Problematisation frameworks hold significant benefits for baseline studies, as these facilitate not only gap spotting in terms of existing knowledge, but also a critique of existing assumptions underlying knowledge at different levels (Alvesson & Sandberg, 2011).

The layout of the paper is: Firstly, we present the objectives and research questions. We then discuss the research methodology that was followed. Thirdly we present a literature review that focuses on the main aspects that inform our work, these include ODeL frameworks, supervision frameworks, the science of Computing research, and the notion of problematisation. We then present our own problematisation framework with a discussion and finally we conclude and indicate possible future work.

2. Research Questions and Objectives

2.1 Problem Statement

Research into the supervision of graduate students in Computing in an ODeL context is fragmented. To the best knowledge of the authors there is no framework that can be used to provide a fuller and more connected view of the nature, focus and diversity of existing research related to this focus area. Furthermore, the diverse nature of the intersecting areas (i.e., ODeL, supervision and Computing as a discipline requires an approach that will allow for a systematic view of not only the existing knowledge in the field, but also the different assumptions and schools of thought that inform existing knowledge in the research area.

2.2 Research Aim and Objective

The aim of this paper is to present a conceptual and generic problematisation framework that can be used to systematically show existing problematisations in the research area of graduate supervision in Computing in an ODeL environment. In line with views expressed by Alvesson & Sandberg (2011) the framework will assist in providing an overview of the fundamental points of departure, underlying assumptions, and conceptualisations as well as the focus and extent of existing knowledge in this research area and thus highlighting knowledge gaps and challenges that could be addressed by future research projects. A secondary aim of the paper is to provide concrete examples of how existing knowledge (from literature) can be categorised (as existing problematisations) using the proposed framework.

2.3 Research Questions

Our research questions addressed in this paper are:

- What are the problematisation aspects elucidated in the literature? (RQ1)
- What is an appropriate framework to structure the problematisation of postgraduate supervision in Computing in an ODeL environment? (RQ2).

2.4 Conceptual and Theoretical Foundations of the Study

The fundamental assumption underlying the is that nature of science is essentially social, and that it is possible to identify different communities of scientists working in a research area around common worldviews and within different schools of thought on how to deal with the research problem area (Orman, 2016). The proposed problematisation framework for postgraduate supervision of computing students in an ODeL environment presented in this paper therefore departs from the conceptual position of what Stengers (2021) aptly describes as "*…the social constructionist demystification of the claimed rationality of scientific progress*" (Stengers, 2021, p. 75).

2.5 Research Methodology

Our research methodology follows Saunders et al.'s (2018) Research Onion depicted in **Figure *3***.

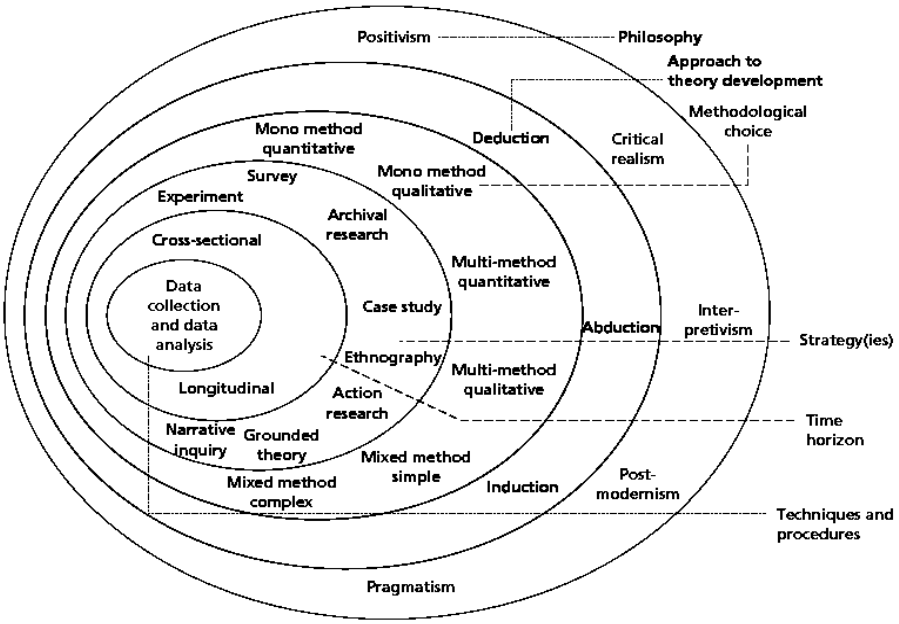

Figure 3: Saunders et al.'s Research Onion (2018)

Our research philosophy is essentially interpretivist in that text and diagrams in scholarly literature are interpreted in a qualitative fashion. With respect to the research approach, we note that since we develop a problematisation framework for aspects in postgraduate supervision of Computing students, we work both inductively and deductively. While the deductive component may be small compared the inductive deliverable, further research intends to perform a more comprehensive validation of the problematisation framework.

The methodological choice in this paper is mono qualitative, since, as indicated in our research philosophy we are studying literature with respect to problematisation around epistemological paradigms, metaphors, and puzzle-solving concepts. The strategy followed is around aspects of literature survey coupled with cases embedded in these. Our time horizon is cross-sectional since the research in this paper is conducted at a specific point in time. That said, the ongoing nature of this project will lead us into a longitudinal time horizon. At this stage our data collection and analyses involve a hermeneutic engagement with scholarly literature on postgraduate supervision and problematisation. Future work has the possibility of involving surveys among stakeholders in this area, amongst others postgraduate students and supervisors in ODeL institutions.

3. Literature Review

We note (as previously indicated) that our work formalizes and significantly expands an idea presented in a talk at a Unisa ODeL conference for Science Engineering and Technology (Van der Poll & Lotriet, 2013).

The literature review considers related work in the main areas of ODeL and distance education, models of graduate supervision, the science of Computing, and the notion of problematisation.

3.1 ODeL and Distance Education

Distance Education, or the preferred term in Europe and Africa – Open-Distance e-Learning (ODeL) - has been extensively researched owing to its specific nature (Simonson *et al.*, 2011). At the core of ODeL is tuition and learning. Therefore, the traditional paradigms of education, as set out in classical learning theories of Behaviourism, Cognitivism, Constructivism (and Connectivism) (Kop & Hill, 2008) informs ODeL. Dominant schools of thought in ODeL include amongst others the conceptualisation by Peters of ODeL as industrial action (Keegan, 2013), Moore's Theory of Transactional Distance (Moore, 2013) and Moore and Kearsley's (2013) systems view of ODeL. It should be clear that the diverse schools of thought around ODeL allow for multiple opportunities of problematisation that relate to supervision at a distance.

3.2 Models/Frameworks of Postgraduate and/or M&D Supervision

There are widespread recent arguments that postgraduate supervision should be seen as a form of tuition, rather than primarily focused on the methodological and discipline based (McCallin & Nayar, 2012; Zeegers & Barron, 2012). The view of graduate supervision as pedagogically informed means that the fundamental learning theories in education as set out in the previous section would also provide the paradigms that inform graduate supervision.

Various models and frameworks of postgraduate supervision exist. These include what is considered to be the "traditional" widely used apprenticeship model, which is still dominant and in which a single student is supervised by one or more supervisors (le Grange & Newmark, 2002). However, changing realities, such as the changing nature of knowledge, and the external pressure to produce increasing numbers of graduate students have resulted in alternative supervisory models being explored (Le Grange & Newmark, 2002, *op. cit.*). These include models such as cohort supervision (Van Biljon & de Villiers, 2013; Van Biljon *et al.*, 2019), and project-based cohorts (Winberg & Winberg, 2018), communities of practice (Manyike, 2017), and knowledge management informed models (Zhao, 2003).

ODeL adds the dimension of mediated interaction to postgraduate supervision. The pressure of massification of education, which also includes massified delivery of graduate students means that the discourses around models of postgraduate supervision have extra urgency in the ODeL context.

3.3 The Science of Computing

The field of Computing research is characterised by features that presents unique challenges. The first one of these is the diverse and fragmented nature of the field and the variety of views on what would constitute meaningful research within this context (Tarafdar & Davidson, 2018), with research areas ranging from algorithms and formal logic (as examples) on the one end of the research spectrum, to phenomenological studies of adoption and use of technologies, and structures of power and domination on the other side of the research spectrum. Furthermore, the field is often interdisciplinary in nature, not only with other Computing-related areas, but multiple other disciplines as well (see for instance Davis, 2010), which requires care from both supervisors and graduate students in the process of completing graduate degrees.

A second major complexity is caused by the rapid advancement and development of computing technologies and associated changes in operational and other issues. The impact on computing research is the challenge for researchers (supervisors and students) to keep up with the rapid progression (see for instance Korunka & Hoonakker, 2014), and the resultant short shelf-lives of many technology-focused research findings. A further challenge related to this is the wide diversity of theories adopted by researchers to explain and describe technology-related phenomena in many areas of computing-related research (Gregor, 2002).

Although Computing-related research is generally doable within an ODeL environment, one complication that is worth highlighting relates to Computing research requiring laboratory facilities and the access to such facilities by ODeL students or finding virtual equivalent spaces that the students can use (Mahanta & Sarma, 2012).

3.4 Problematisation

At a conceptual level, problematisation frameworks can be traced back to the work of Foucault and Kuhn (Frederiksen et al., 2015; Morgan, 1980) amongst others. For Foucault the essence of problematisation lay in seeing the way in which that which is familiar becomes unfamiliar, thus raising issues that need to be considered (Frederiksen et al., 2015, *op. cit.*).
A problematisation framework assists with the provision of "intertextual coherence", and in problematizing existing literature to justify further research, which ultimately allows for demonstration of scientific contribution, as in Locke & Golden-Biddle (1997).

To develop our problematisation framework, described in the next section, we adopted a three-tiered model proposed by Morgan (1980), based on Kuhnian concepts of the nature of science. The work of Morgan is seminal, and recent authors have pointed out its continued relevance in terms of its conceptualisation of problematisation. Thus, for example Alvesson and Spicer (2019) reiterate the importance of the organisation of knowledge around a root metaphor, while Breslin and Gatrell (2020) point out that Morgan's work allows for the awareness of possibilities beyond the confines of current knowledge, the possibility of exploitation of these possibilities in terms of conceptualisations, metaphors, and inter- and multidisciplinary insights.

The top tier of Morgan's model represents the fundamental lenses with which scientists view their realities. These paradigms could be considered to separate (broadly) different scientific communities of practice (Kuhn, 1974). The middle tier represents the language and concepts (or metaphors) used by scientists to describe the understanding of their worlds. In practical terms for the purpose of this paper these metaphors would represent the different "schools of thought" among scientists regarding the phenomena being investigated. The bottom tier represents the "normal" routine scientific work that scientists would do to examine a phenomenon, what Kuhn termed as "puzzle solving" (Morgan, 1980, *op. cit.*).

A diagram illustrating the three tiers appear in **Figure 4**.

In the context of this paper, our problematisation framework would examine the intersection of three sets of paradigms, schools of thought and puzzle solving that would represent ODeL, postgraduate supervision and computing. The discussions in this section answer our RQ1.

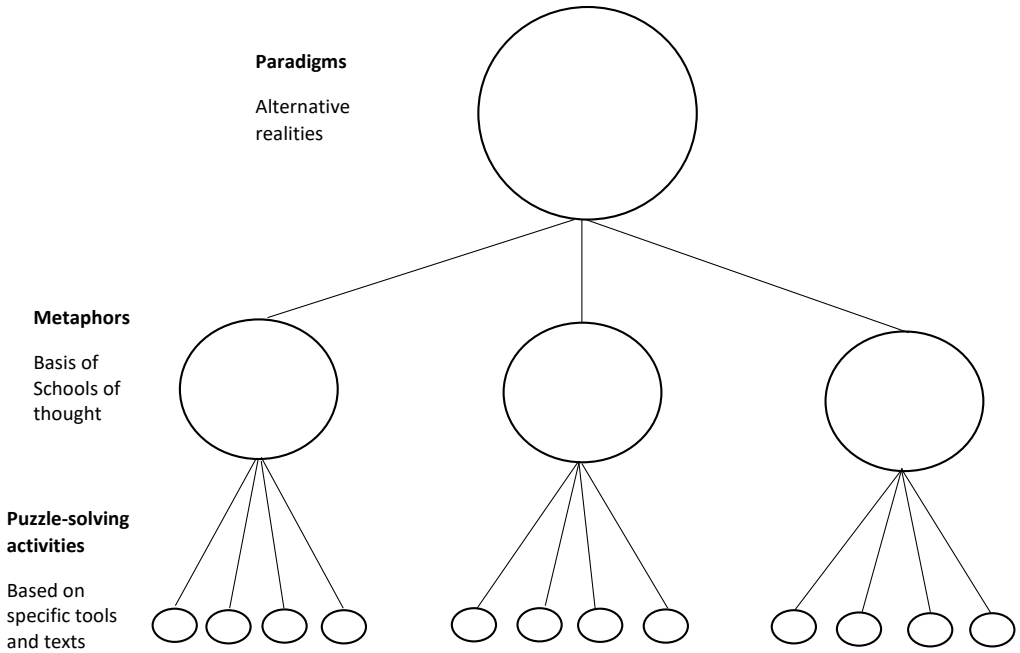

Figure 4: Paradigms, metaphors, and puzzle-solving (Morgan, 1980)

4. Our Problematisation Framework

Our proposed problematisation framework is presented in Table 1. The top tier of the framework encompasses the paradigms of ODeL, graduate supervision, and the science of Computing. The middle tier represents the schools of thought that describe ODeL, graduate supervision and science of Computing. The lowest tier represents the normal scientific activity related to ODeL, graduate supervision and the science of Computing.

Instantiations of problematisations that could relate to the various dimensions of the problematisation framework are presented in Table 2. Examples are synthesized to illustrate the application of the framework to postgraduate ODeL supervision. These are not in any way intended to be complete, but simply serve as an example of the categorization of problematisations that the framework allows for.

Table 2: Proposed top tier problematisation framework (expanded and developed from Morgan (1980).

Paradigms (World views)
The impact of dominant paradigms in the domains of ODeL, Graduate Supervision and Computing research impact on supervision of graduate Computing students in an ODeL environment.
Schools of thought (metaphors)
The impact of schools of thought in the domains of ODeL, Graduate Supervision and Computing research on supervision of graduate Computing students in an ODeL environment.
Activities, tools, models & texts
The impact of activities, tools, models & texts in the domains of ODeL, Graduate Supervision and Computing research on supervision of graduate Computing students in an ODeL environment.

Table 3: Examples of problematisations (framework expanded and developed from Morgan (1980).

Tier	ODeL	PG Supervision	Computing
Paradigms **(World views)**	How do the major paradigms of ODeL (and PG supervision), i.e., Behaviourist, Cognitivist, Constructivist and Constructionist (Kop & Hill, 2008) impact on ODeL Computing supervision?		How do the major paradigms/epistemological approaches of Computing research (Hassan & Mingers, 2018) impact on ODeL Computing supervision?
Schools of thought	How do views of ODeL as, for example, industrial activity (Peters) or as systems (Moore et al.) or ODeL as care (Holmberg) impact on ODeL Computing supervision?	How do schools of thought on the nature of graduate supervision, e.g. as collaborative (apprenticeship model (Manyike, 2017), community of practice (Manyike, 2017), or project-based cohorts (Winberg & Winberg, 2018)) impact on ODeL Computing supervision?	How do the schools of thought on Computing Research (e.g., quantitative, survey-based schools of thought (Chen & Hirschheim, 2004) vs. for instance, researcher as agent (action research and design science) (Järvinen, 2007) vs. importance of "real research" (Chen & Hirschheim, *op. cit*.) impact on the ODeL Computing supervision?
Activities, tools, models & texts	How do, for example ODeL activities during pandemic (Koçoglu & Tekdal, 2020) impact on ODeL Computing Supervision? ODeL system configurations are often incomplete, hence how should these be set up to address pandemics at unforeseen times (researchers' own syntheses)?	How do, for example metaphors related to student engagement practice (Grant *et al.*, 2014) or multicultural student perspectives (Sidhu et al., 2014) impact on ODeL Computing supervision? How much scaffolding should be provided, and when (Kashora, 2018)?	How do, for example, Scientific methods in CS (Dodig-Crnkovic (2002) impact on ODeL computing supervision? To what extent do Computing students need assistance with the configurations of their systems (researchers own experiences)?

Tier	ODeL	PG Supervision	Computing
	What kind, and level of training should be offered for both students and supervisors in ODeL Learning Management Systems (LMSs) (researchers' own syntheses)? How should ODeL be utilised to not just introduce it for the sake of having the latest technology, i.e., treating a symptom instead of the cure (Akor, 2015)? Linking with the above, how could the ODeL experience be enhanced using technologies such as mobile devices (Amhag, 2017), hence impact ODeL Computing supervision? How should the vast possibilities and at the same time major pitfalls of the 4IR for students and supervisors be managed in ODeL (researchers' own syntheses)?	What functionality do supervisors need to give optimal service to postgraduate students (researcher's own syntheses)? Linking with the above, what systems do the students need (researchers' own syntheses)? What training with respect to technical aspects, RM, and soft skills should be offered to supervisors (researchers' own syntheses)? How should power relations during a supervision experience be managed (Frederiksen et *al*., 2015; Akor, 2015)?	Would it be reasonable to expect of students in a resource-strained, developing economy to procure their own laptops? If not, how should their systems be configured by the university's ICT to avoid the challenges indicated on the left (researchers' own experiences)?

Tables 1 and 2 answer our 2nd research question and meet our objective stated in Section 2.2.

5. Discussion of the Framework

We believe that the three-tiered approach that we propose provides a holistic view in terms of problematizing the scientific research field at the intersection of ODeL, Graduate Supervision and Computing Research.

In principle the proposed framework is the opposite of other frameworks used in ODeL, such as for example the popular "trends" framework by Zawacki-Richter (2009), which was compiled on the basis of existing research and therefore characterizes the existing scientific field in a grounded and empirical manner. Approaches similar to Zawacki-Richter's work were used by for instance Redmond *et al.* (2018) in the development of their online engagement framework. Although these frameworks are useful to situate new research in the context of existing knowledge, we argue that for the purpose of the identification of new meaningful research areas and research fields, having a framework that allows for explicit consideration of the underlying paradigms, assumptions and conceptualisations is a more powerful research tool.

5.1 Paradigms & Schools of Thought (Tiers 1&2)

We would argue that problematisation of the higher tiers, especially the paradigmatic tier would be much scarcer in literature, as problematising the lens through which the phenomenon is examined would probably only happen under the conditions where an intractable challenge is encountered that requires a major paradigm shift (or in Kuhnian terms, a 'scientific revolution') (Kuhn, 2012). In an ODeL context the conceptualisation of connectivism as a lens for tuition and learning has been argued to be a relatively recent example of such a paradigm shift, in response to the interconnected realities of the current world (Santas, 2015).

Similarly, the coming into existence of major new schools of thought in any of the intersecting domains can be considered rare. Thus, the foundational conceptualisations of ODeL, such as autonomy, industrial activity, transactional distance and openness (Jung, 2019) were developed in the 20th century. Even conceptualisations that are considered to be "new" such as community of enquiry or heutagogy (as extension of pedagogy and andragogy) (Jung, 2019, *op.cit.*) are already a decade old. It would be interesting to see if the current world conditions (e.g., the raging pandemic, climate change and geopolitical crises) would trigger a knowledge crisis that would jolt scientists out of working in the lower tiers of our framework and develop new schools of thought around ODeL, graduate supervision and Computing research.

5.2 Activities, Tools, Models & Texts (Tier 3)

In Kuhnian terms, the normal scientist would engage mainly at solving research problems at the lowest tier (Kuhn, 2012). As our examples indicate, these would mainly relate to the conceptualisation of operational issues, the lived experiences of participants, and the creation of enabling environments. for students. Scientific findings corresponding to this tier could be expected to have mainly localised and short-range impacts.

An interesting technology-related example of the familiar becoming the unfamiliar may be the technological advances of the Fourth Industrial Revolution (4IR) and the Fifth Industrial Revolution (5IR) closely on its heels of the 4IR. Students are increasingly exposed and tempted by the use of all kinds of software assistants. Apart from the usual tools, e.g., statistical packages (SPSS, R, and others) and language tools like Grammarly (Oneill & Russell, 2019), thesis generators are not so far-fetched. While there are ethically suspect human services offered for writing a dissertation or thesis on behalf of the student, the more interesting and challenging scenario would be intelligent software or robots

that could generate a thesis starting from a contemporary natural language specification and a set of carefully defined keywords. For an example of the state of development in natural language specification see Dušek & Jurcicek (2015). While such practices are currently highly irregular and unethical, it is plausible that in next generations these may become acceptable practices. Be that as it may, aspects of the 4IR with respect to Artificial Intelligence, Machine Learning, and other technologies, albeit currently still on the horizon of postgraduate supervision may trigger scientific advances.

6. Conclusion and Future Work

6.1 General

In this paper we considered the notion of problematisation as it relates to postgraduate supervision of Computing students in an ODeL environment. To do this we surveyed the notion of problematisation in literature and the various schools of thought around this concept. We propose a three-tier problematisation framework based on the seminal work of Morgan (1980) (Figure 3) as appropriate for a systematic view of areas of problematisation in our research focus area. We customised this framework for our research focus area (Table 1). We provided examples of problematisation in ODeL, Postgraduate supervision and Computing Research and indicated how these could trigger research questions in the research focus area (Table 2).

6.2 Contribution Made by This Paper

The paper, therefore, contributes by providing a coherent holistic structure that can be used to relate not only the normal scientific knowledge in the research area at the intersection of ODeL, graduate supervision and Computing, but also the underlying schools of thought and fundamental scientific communities of practice. Thus, the proposed framework deviates from other frameworks in use, that are based on grounded categorisations of existing knowledge mainly in the field of ODeL. The framework provides a potentially powerful tool for the identification of potentially interesting and relevant research questions within the research area.

6.3 Future Work

Further phases of our work include a systematic review of literature in the area of supervision of graduate Computing students in an ODeL environment, in which we apply the proposed framework to provide a systematic view of existing research (and problematisations) at the proposed tiers. Based on this, a literature-founded view (and framework) of best practices based on scientific findings can be proposed. Further work could include validation of the framework among stakeholders (students, supervisors and others) using a Delphi-based approach similar to the validation approach used by Zawacki-Richter (2009). It is expected that use of the framework will allow the identification of meaningful future research projects in our research area.

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7. References

Akor, O. (2015). Problematization: The Foundation of Sustainable Development. In *International Conference on African Development Issues (CU-ICADI)*, 77 – 83.

Alvesson, M., & Sandberg, J. (2011). Generating research questions through problematization. *Academy of management review*, 36(2), 247-271.

Alvesson, M., & Spicer, A. (2019). Neo-institutional theory and organization studies: a mid-life crisis? *Organization Studies*, 40(2), 199-218.

Amhag, L. (2017). Mobile-Assisted seamless learning activities in higher distance education. *International Journal of Higher Education*, 6(3), 70-81.

Baskerville, R. (2008). What design science is not. *European Journal of Information Systems*, 17(5), 441-443.

Bitzer, E. M., & Albertyn, R. M. (2011). Alternative approaches to postgraduate supervision: A planning tool to facilitate supervisory processes. *South African Journal of Higher Education*, 25(5), 875-888.

Breslin, D., & Gatrell, C. (2020). Theorizing through literature reviews: The miner-prospector continuum. *Organizational Research Methods*, 1094428120943288.

Calitz, A. P., Greyling, J., & Glaum, A. (2016). CS and IS alumni post-graduate course and supervision perceptions. In Gruner S. (ed) *ICT Education. SACLA 2016. Communications in Computer and Information Science*, 642, (115-122). Springer, Cham.

Chen, W., & Hirschheim, R. (2004). A paradigmatic and methodological examination of information systems research from 1991 to 2001. *Information Systems Journal*, 14(3), 197-235.

Davis, N. (2010). Global interdisciplinary research into the diffusion of information technology innovations in education. In *Researching IT in Education* (158-166). Routledge.

Dodig-Crnkovic, G. (2002, April). Scientific methods in computer science. In *Proceedings of the Conference for the Promotion of Research in IT at New Universities and at University Colleges in Sweden*, Skövde, Suecia (126-130).

Dušek, O., & Jurcicek, F. (2015, July). Training a natural language generator from unaligned data. In *Proceedings of the 53rd Annual Meeting of the Association for Computational Linguistics and the 7th International Joint Conference on Natural Language Processing* (Volume 1: Long Papers) (pp. 451-461).

De Oliveira, M. M. S., Penedo, A. S. T., & Pereira, V. S. (2018). Distance education: advantages and disadvantages of the point of view of education and society. *Dialogia*, (29), 139-152.

Erichsen, E. A., Bolliger, D. U., & Halupa, C. (2014). Student satisfaction with graduate supervision in doctoral programs primarily delivered in distance education settings. *Studies in Higher education*, 39(2), 321-338.

Frederiksen, K., Lomborg, K., & Beedholm, K. (2015). Foucault's notion of problematization: A methodological discussion of the application of Foucault's later work to nursing research. *Nursing Inquiry*, 22(3), 202-209.

Grant, K., Hackney, R., & Edgar, D. (2014). Postgraduate research supervision: An'agreed'conceptual view of good practice through derived metaphors. *International Journal of Doctoral Studies*, 9, 43-60.

Gregor, S. (2002). A theory of theories in information systems. In *Information Systems Foundations: building the theoretical base*, 1-20.

Halse, C., & Malfroy, J. (2010). Retheorizing doctoral supervision as professional work. *Studies in Higher education*, 35(1), 79-92.

Hassan, N. R., & Mingers, J. (2018). Reinterpreting the Kuhnian paradigm in information systems. *Journal of the Association for Information Systems*, 19(7), 6.

Järvinen, P. (2007). Action research is similar to design science. *Quality & Quantity*, 41(1), 37-54.

Jung, I. (Ed.). (2019). *Open and distance education theory revisited: Implications for the digital era*. Singapore: Springer.

Kassegne, S. K. (2006, October). Work in Progress: Lessons from Virtual Supervision of Engineering and Computer Science Graduate Students-Case of Addis Ababa University. In *Proceedings. Frontiers in Education*. 36th Annual Conference, 23-24. IEEE.

Keegan, D. (2013). *Otto Peters on distance education: The industrialization of teaching and learning.* Routledge.

Koçoglu, E., & Tekdal, D. (2020). Analysis of Distance Education Activities Conducted during COVID-19 Pandemic. *Educational Research and Reviews*, 15(9), 536-543.

Kop, R. & Hill, A. (2008). Connectivism: Learning theory of the future or vestige of the past? *International Review of Research in Open and Distributed Learning*, 9(3), 1–13.

Korunka, C., & Hoonakker, P. (2014). The future of ICT and quality of working life: Challenges, benefits, and risks. In *The impact of ICT on quality of working life*, 205-219. Springer, Dordrecht.

Kuhn, T.S. (2012). *The structure of scientific revolutions (4th ed.).* Chicago: University of Chicago Press.

Kuhn, T.S. (1974). Second thoughts on paradigms. In F. Suppe (Ed.) *The structure of scientific theories* (pp. 459 – 482). Urbana, IL. University of Illinois Press.

Le Grange, L., & Newmark, R. (2002). Postgraduate research supervision in a socially distributed knowledge system: some thoughts: perspectives on higher education. *South African Journal of Higher Education*, 16(3), 50–57.

Lee, A. & Green, B. (1995). Introduction, postgraduate studies/postgraduate pedagogy? *The Australian Universities' Review,* 38(2), 2-4.

Locke, K., & Golden-Biddle, K. (1997). Constructing opportunities for contribution: Structuring intertextual coherence and "problematizing" in organizational studies. *Academy of Management journal*, 40(5), 1023-1062.

Mahanta, A., & Sarma, K. K. (2012). Online resource and ICT-aided virtual laboratory setup. *International Journal of Computer Applications*, 52(6).

Manyike, T. V. (2017). Postgraduate supervision at an open distance e-learning institution in South Africa. *South African Journal of Education*, 37(2).

McCallin, A., & Nayar, S. (2012). Postgraduate research supervision: A critical review of current practice. *Teaching in Higher Education*, 17(1), 63-74.

Moore, M. G. (2013). The theory of transactional distance. In *Handbook of distance education,* 84-103. Routledge.

Moore, M. G., & Kearsley, G. (2011). *Distance education: A systems view of online learning.* Cengage Learning.

Morgan, G. (1980). Paradigms, metaphors, and puzzle solving in organization theory. *Administrative science quarterly*, 605-622.

Orman, T.F. (2016). "Paradigm" as a Central Concept in Thomas Kuhn's Thought. *International Journal of Humanities and Social Science*, 6(10), 47 – 52.

Pearson, M. (1999). The changing environment for doctoral education in Australia: Implications for quality management, improvement and innovation. *Higher Education Research & Development*, 18(3), 269-287.

Ramukumba, M. (2015). Using mobile devices in supervision of graduate research in distance education: A personal journey. In *International Conference on Mobile and Contextual Learning,* 1-14. Springer, Cham.

Redmond, P., Abawi, L. A., Brown, A., Henderson, R., & Heffernan, A. (2018). An online engagement framework for higher education. *Online learning*, 22(1), 183-204.

Rodger, S., & Brown, G. T. (2000). Enhancing graduate supervision in occupational therapy education through alternative delivery. *Occupational therapy international*, 7(3), 163-172.

Sandberg, J., & Alvesson, M. (2011). Ways of constructing research questions: gap-spotting or problematization? *Organization*, 18(1), 23-44.

Sarıtaş, M. T. (2015). The emergent technological and theoretical paradigms in education: the interrelations of cloud computing (CC), connectivism and internet of things (IoT). *Acta Polytechnica Hungarica*, 12(6), 161-179.

Saunders, M., Thornhill, A. & Lewis, P. (2018). *Research Methods for Business Students, 8th Edition*, London, Pearson.

Sidhu, G.K., Kaur, S., Fook, C.Y. and Yunus, F.W. (2014). Postgraduate supervision: Comparing student perspectives from Malaysia and the United Kingdom. *Procedia-Social and Behavioral Sciences,* 123 (2014): 151-159.

Simonson, M., Schlosser, C., & Orellana, A. (2011). Distance education research: A review of the literature. *Journal of Computing in Higher Education*, 23(2), 124-142.

Stengers, I. (2021). Putting problematization to the test of our present. *Theory, Culture & Society*, 38(2), 71-92.

Tarafdar, M., & Davison, R. M. (2018). Research in information systems: Intra-disciplinary and inter-disciplinary approaches. Journal of the Association for Information Systems, 19(6), 2.

Van Biljon, J., Pilkington, C., & van der Merwe, R. (2019, July). Cohort Supervision: Towards a Sustainable Model for Distance Learning. In *Annual Conference of the Southern African Computer Lecturers' Association*, 147-162. Springer, Cham.

Van Biljon, J. A., & De Villiers, M. R. (2013). Multiplicity in supervision models: The supervisor's perspective. *South African Journal of Higher Education*, 27(6), 1443-1463.

Van der Poll & Lotriet (2013). *Towards a framework for ODL supervision of South African master's and doctoral students in computing.* Talk presented at CSET ODL conference at the University of South Africa. Abstract downloaded from https://nanopdf.com/queue/book-of-abstracts-5ae1a8f6464c8_pdf?queue_id=-1&x=1623199943&z=MTAyLjE4Mi4xOTcuMjIz. (No full paper exists.)

Winberg C & Winberg S. 2018. More than writing a thesis - Reflections on cohort research supervision. In Bitzer EM, Frick, BL, Fourie-Malherbe M & Phyältö K (eds): Spaces, journeys and new horizons for postgraduate supervision. Stellenbosch: African Sun Media, 93-108.

Zawacki-Richter, O. (2009). Research areas in distance education: A Delphi study. *International Review of Research in Open and Distributed Learning,* 10(3) 2009.

Zeegers, M. and Barron, D. (2012), Pedagogical concerns in doctoral supervision: a challenge for pedagogy, *Quality Assurance in Education*, 20(1), 20-30.

Zhao, F. (2003). Transforming quality in research supervision: A knowledge-management approach. *Quality in higher education*, 9(2), 187-197.

Problematising the Teaching of Formal Methods (FMs) in Open Distance e-Learning (ODeL)

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Abstract
The steep learning curve in mastering essential discrete mathematics and logic makes the teaching of formal methods (FMs) as part of a software engineering programme mandated by the ACM/IEEE challenging, even in a face-to-face environment. These challenges are compounded in a distance teaching environment, known as online teaching or Open Distance e-Learning (ODeL) through a Learning Management System (LMS). Some researchers report success with the teaching of FMs in face-to-face laboratory work, but with the Covid-19 pandemic even those institutions had to resort to online. While pandemics may pass, traditional ODeL institutions continue to deal with the challenges of online and blended tuition of FMs, while still being faced with the general mathematics-FMs online teaching challenges. In this paper we synthesise the challenges of the ODeL of FMs as elucidated in the literature as well as experienced by the researchers through the teaching of FMs material. Challenges around the ODeL of FMs and the Moodle LMS are unpacked and on the strength of these challenges a problematisation framework for the ODeL of FMs is developed. The framework aims to synthesise the challenges around the teaching of the said concepts and is theoretically validated. Future work would include the validation of the framework and development of a solution framework to address the problematisations.
Keywords: Distance Teaching, Formal Methods (FMs), Learning Management System (LMS), Moodle, Open Distance e-Learning (ODeL), Problematisation

1. Introduction

The teaching and subsequent use of Formal Methods (FMs) in software engineering courses at higher education institutions are met with mixed responses (Jeppu et *al*., 2017). Advocates of FMs, based on the notion of a formal specification followed by reasoning about the properties of the specification, point to numerous advantages of the use of FMs. These include the development of high-quality software, the ability to show the resultant system meets its specification and undesirable consequences are absent from the specification (Woodcock & Davies, 1996; Basile, 2018). Those generally not in favour of FMs point out that the use of underlying discrete mathematics and logic in formal specification work is hard, formal specifications in the literature contain errors, and the return on investment (ROI) of learning these formalisms are low (Rushby, 1993; Parnas, 1998). Nevertheless, the Joint Task Force on Computing Curricula, Association for Computing Machinery (ACM) and IEEE Computer Society (2013) and the Formal Methods Body of Knowledge (Formal Methods Wiki: Projects FMBoK, n.d.) established in 2009 support the teaching of FMs as part of a software engineering curriculum. Yet, the sparseness of general best practices for FMs is an added challenge. For example, papers in the FMs support group concentrate on specifications for specific applications, e.g., Information Security (see Papers | GRACEセンター (grace-center.jp) and not on general best practices for FMs.

A main challenge in teaching FMs stems from the perceived complexity of the underlying mathematics (Alexandru, 2019), echoed by Naidoo & Singh-Pillay (2021) through their investigations of the perceptions of postgraduate mathematics education students during the Covid-19 pandemic. Cao et al. (2021) identified the online-mathematics teaching combination to be likewise challenging during the pandemic. The industry also presents a challenge in accepting FMs as part of the software

development process. Similar challenges arise in technical subjects, for example, Mathematics or Physics, and, of course, discrete mathematics and logic underlying FMs are indeed part of Mathematics. Yet, FMs in the computing milieu have added challenges in that software, often involving distributive and parallel aspects (Niculescu, 2020) must be catered for. While the teaching, and comprehension of the concepts by the students are hard in a face-to-face environment, ODeL adds further complexity. We suggest in this paper as a first step in addressing these challenges the development of a problematisation framework for the ODeL of FMs.

We note that our work is conceptualised from a talk at a CSET ODeL conference (van der Poll & Dongmo, 2013) on challenges with the online teaching of FMs, and for which no full paper exists.
The layout of the paper is: Research questions and an objective are given in Section 1.2. Research methodology appears in Section 2.0, followed by a literature review on FMs with reference to abstract- and procedural specifications in Section 3.0. ODeL aspects linked to the teaching of FMs, including the role of Moodle are given in Section 4.0. A discussion of problematisation as per the literature appears in Section 5.0. Our problematisation framework is given in Section 6.0, followed by a theoretical validation in Section 7.0. Conclusions and future work in this area appear in Section 8.0, followed by a list of references.

1.2 Research Questions (RQs) and Objective

Our research aims to find answers to the following RQs:

- What are the notational complexities with respect to formal specification in the use of FMs in software engineering? (RQ1)
- What challenges do FMs teaching pose to ODeL and an underlying LMS, namely, Moodle? (RQ2)

Our objective to find answers to the above RQs is:

- Develop a problematization framework to elicit the challenges of the ODeL of FMs.

2. Research Methodology

Our research is conducted in line with Saunders et al.'s (2018) Research Onion in **Figure 5**.

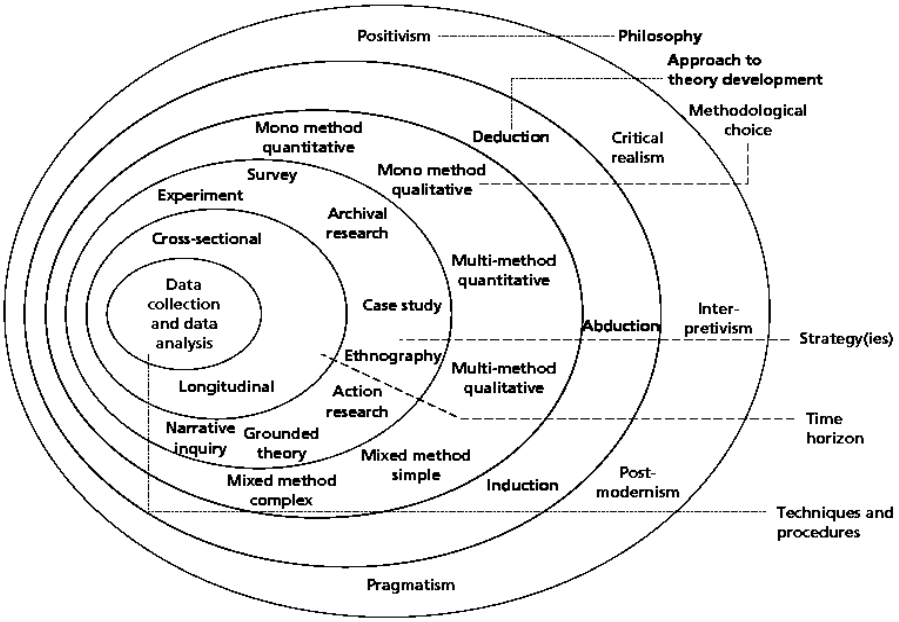

Figure 5: Saunders et al.'s (2018) Research Onion.

From the outer layer, our philosophy embeds positivism and interpretivism. It is positivist owing to the FMs component in our work, and interpretivism stems from qualitative text and diagrams in the literature. At the next layer, our approach is largely inductive since we develop a problematisation framework. The framework is briefly validated through a theoretical discussion hence we also have a small deductive component. The methodological choice is mixed – qualitative and quantitative. The FMs add a quantitative part (albeit it being discrete mathematics and logic, and not statistics per se), and the qualitative part follows from the literature review. Our strategy is mainly a case study since we discuss formal specification constructs, both at the abstract and procedural levels. A cross-sectional time horizon is followed since this research is conducted at a specific point in time. The data collection and analyses are through the literature.

3. The Use of FMs – Specification and Reasoning

Traditionally, the teaching of FMs may follow any of a number of approaches. The *abstract* specification technique constructs a formal specification, followed by reasoning about the properties of the specification. Should any inconsistencies in the specification be revealed, it is revisited and corrected (Potter et *al*., 1996). Texts on the *procedural* approach embody high-level language constructs and apply various proof rules to show correctness (Backhouse, 2003). Other approaches include correctness by construction (Kourie & Watson, 2012), or object-orientation (Dahl, 1992).

The authors of this paper have worked in the areas of formal specification, program verification and reasoning and have found most of the approaches to be that of abstract specification and procedural, high-level program constructs. Consequently, these are addressed in this paper.

3.1 Abstract Specification Approaches

Various abstract specification styles have been defined. Algebraic specifications view a system as a set of axioms that are to hold throughout the life of the system (Goguen, 2000); the process-based approach defines a system as a set of co-operating processes (Palshikar, 2001); and the model-based style, e.g., Z (Potter et *al*., 1996) specifies a system as a state accompanied by operations. For the purposes of this paper, the model-based specification style is discussed.

Example 1: Suppose a government introduces a national identity scheme for football fans where each fan is allocated a single, unique identity code. The system must keep track of who has been allocated which identity code. It must also keep a list of the identity codes of all troublemakers who have been banned from attending matches (adapted from Potter et *al*., 1996).

A specifier starts by defining the Basic Types of the system, say *ID* and *PERSON*, followed by a state space, *Fid*:

Fid

$$members : ID \pfun PERSON$$
$$banned : \mathbb{P}\ ID$$

$$banned \subseteq \text{dom}\ members$$

Adding a new member may be specified as:

AddMember

Δ *Fid*

applicant? : *PERSON*; *id*! : *ID*

---

applicant? $\notin$ ran *members* $\wedge$ *id*! $\notin$ dom *members*

members′ = *members* $\cup$ {*id*! $\mapsto$ *applicant*?}

banned′ = *banned*

The new member (*applicant*?) should not be a member already; the system generates a new *id*! for the member; the member is added, and the set of all banned members remains invariant. Several insights should be conveyed through this specification to a student:

- The set (type) *ID* denotes a maximal set, i.e., the set of all possible identity codes.
- The set *members* is a partial injection, consequently:
  - every member has a unique id (injectivity).
  - at any given time not all the identity codes are used (partiality)
- A precondition to the *AddMember* operation should be (formally) calculated.
- Proof obligations (POs) should be stated and discharged. For example, it should be stated and shown that a banned member cannot apply and be enrolled with another identity code.
  - A PO can be discharged manually (by hand), but preferably by a/an (automated) reasoner. Or should an interactive reasoner that guides the specifier be preferred?

Example 1 illustrates earlier claims that FMs involve a steep learning curve for software developers. Plausibly, aspects illustrated in the example can be conveyed more easily in a face-to-face, classroom environment than using ODeL. This aspect is discussed further in this paper.
Next, we consider specification using the *procedural* paradigm.

3.2 Procedural Approaches

Example 2: Consider examples of procedural code constructs in a typical program verification course taught by the researchers. Questions to be answered about each construct are as indicated.

Sequence of statements	If-then-else	While loop
Question: Determine the weakest precondition (*wp*) for the given postcondition (P).	**Question:** Determine the weakest precondition (*wp*) for the given postcondition (P).	**Question:** Verify {P} S {Q} where S is the following while loop:

{?}
t := x;
x := y;
y := t
{x = Y ∧ y = X} = {P} (postcondition)
	{?}
	if even (x) **then** x := x – 1;
	elseif odd (x) **then** z := z + y;
	fi
	{0 ≤ x ∧ z + y * x = a * b} = {P}
		{n > 0} = {P}
		i := 1;
		while (2 * i ≤ n) **do**
		i := 2 * i;
		endwhile
		{(0 < i ≤ n < 2 * i) v (i = 2p for some value of p)}

		In some versions of this question students could also be asked: • Determine the purpose of the program fragment. (**Answer:** S sets i to the highest power of 2 that is at most n. • Determine the loop invariant. (**Answer:** (0 < i ≤ n) ∨ (i = 2p for some p).

Numerous challenges emerge for students through the above example:

- The notion of working backwards through a sequence of assignment statements using the Assignment Axiom should be known and be applied. E.g., consider {x = ?} x = x + 1 {x = 0}. It should be evident that {x = -1} is the precondition for the given program and postcondition pair. A mechanical way to determine it is by substituting "x + 1" (the right-hand side) in the postcondition and solve for x. For larger programs, this is not easy. The notion of mechanical substitution is what has been coined by Carroll Morgan as "the part where you must not think, just do" (WoFACS, 1998; personal communication). For a sequence, the precondition of a statement becomes the postcondition of the previous statement, repeating the sequence of "do not think" substitution.
- With the if-then-else statement a student has to embark on some form of "parallel thinking", keeping in mind the application of the above rules for the two branches. This sentiment is echoed by Chaudhury et *al*. (2018) for high-performance parallel computing. Students should have a holistic view of the system they are working with, likewise for specification, verification, and reasoning environments.
- Iteration (loops) incur further complications. Like recursion, a student must keep track of multiple environments throughout the loop, and then in reverse order "unpop' these environments to arrive at the final answer. These are further problematised if the body of the loop contains embedded if-then-else statements, each of the branches containing sequences of statements.

As indicated, the above complications are hard, even in a face-to-face environment, hence more so in ODeL. Residential institutions report some success with these through laboratory work coupled with the use of verification environments. Further, the illustrations in the examples are relatively simple,

reminiscent of the objection that FMs are just for toy problems, so with even slightly more complex examples, students may become very lost.

The above examples provide an answer to our RQ1.

The researchers noted over the years that all the verification examples of the type indicated in Example 2 involve numerical calculations, and it is debatable whether all applications can be expressed in numerics, i.e., of a quantitative nature. Plausibly, there are applications in management and business where FMs could usefully be applied for non-numeric constructs, for example, entrepreneurship or strategy. Verification work in both the abstract (Example 1) and procedural (Example 2) domain for non-numeric applications need to be researched, specifically for ODeL. A further aspect noted is that FMs texts seem to adopt either the abstract approach or the procedural approach, but not both. It is as though these two worlds exist in isolation, hence a bridge between these techniques should be constructed.

Agile & Cyclic learning: Niculescu et *al*. (2020) investigated cyclic learning (Fuller et *al*., 2007) to provide students with a comprehensive overview of the area. Both Agile and cyclic learning appear to hold promise for the ODeL of FMs, hence are included in our problematization framework.

FMBoK and Standards: Stefani et *al*. (2006) use efficiency, functionality, reliability, and usability (UX) of the ISO9126 standard for software systems to assess e-learning services. We anticipate these could advance standards with respect to the FMBoK initiative.

Reasoning (theorem-proving): Numerous automated and semi-automated (interactive) reasoners, e.g., OTTER (Wos, 2006), Prover-9 (https://www.cs.unm.edu/~mccune/prover9/) and Event-B/Rodin (Ackermann & van der Poll, 2020) are available to discharge POs arising from a specification. Reasoning being vital in the problematisation of FMs, is included in our framework.

Model-checking: Model-checking, e.g., JSpin (Vescan & Serba, 2020) is useful when a PO does not lend itself to a theorem-proving approach, e.g., when tracing execution sequences of a program through symbolic execution. Therefore, we include model-checking in our framework.

Machine-Learning: Machine Learning (ML) (Nguyen et *al*., 2019) increasingly gained importance with the advent of the Fourth Industrial Revolution (4IR), hence it is included in our framework.

4. ODeLs Linked to FMs

As indicated before, even face-to-face teaching of FMs presents challenges, both to the lecturer and the students having to grasp the concepts. These challenges are compounded in ODeL of FMs as manifested at traditional distance-teaching institutions.

The researchers are employed at a large South African distance-teaching university with ODeL as a niche. For a large part pre Covid-19 pandemic teaching and learning activities were performed using blended learning (Michalikova & Povinsky, 2020) with face-to-face study schools and group visits two to three times per year. With the outbreak of Covid-19, all face-to-face activities were ceased, moving entirely to ODeL. While pandemics may pass, allowing residential institutions to return to face-to-face teaching in a classroom situation, distance-teaching institutions will remain largely ODeL (van der Poll & Dongmo, 2012).

4.1 Challenges and Opportunities in ODeL

Despite the many advantages of ODeL, one of its major drawbacks is the lack of face-to-face teaching, and recent Covid-19 (hard) lockdowns worldwide brought an appreciation of family, friends, and colleagues.

Ban & Yusop (2004) report on the value of role-playing and group work in acquiring a new skill. One of their objectives was to develop the necessary social skills to elicit requirements, construct a specification from the requirements and maintain the specification and resultant system. They also showed subject-matter videos during their sessions. A challenge mentioned by Ban & Yusop (2004) was the lack of specialised software to support assessment. ODeL is challenged by some of these activities: Face-to-face role-playing and the subsequent development of social skills may be largely absent. Videos may be viewed on YouTube or over MS Teams, but the lecturer is absent to pause the video to answer questions.

Ishikawa et *al*. (2015) link with group work by dividing a class into co-operating groups, some for formal specification and others for model checking. They utilised VDM and SPIN and observed a mix of negative- and positive comments on the course. A concern was that some of the negative comments centred around long-lasting issues, i.e., sustainability of FMs, also discussed by Bjørner & Havelund (2014). Ishikawa et *al*. (2015) report on practical laboratory work involving groups of two to three, and again these would be hard to achive in ODeL.

4.2 The Moodle LMS

Moodle is a general, sophisticated, adaptable, and open-source e-learning platform. It does not cater for specialist software, consequently, researchers have either developed their own e-learning environments, or augmented Moodle with specialised tools. Nair et *al*. (2020) augmented Moodle with MATLAB and Cook et *al*. (2015) added a dedicated web-integrated software development- and verification environment. The experiences of the researchers are similar, for example, specific LaTeX style files for Z or Object-Z have to be incorporated, making it hard to devise standard solutions for students using different platforms.

Michalikova & Povinsky (2020) indicate they started online teaching as recently as 2020. The researchers experienced the same at their university, not with online or ODeL per se, but with Moodle. Migration from traditional LMSs to Moodle took place at the beginning of 2021.
The discussions in Section 4.0 answer our RQ2.

5. Problematisation

Morgan (1980) explored the relationships among paradigms, metaphors, and puzzle solving, showing how organisation theory and research are defined on a set of assumptions that are taken for granted. It proposes that people (and, therefore, software developers), with few exceptions accept the environment in which they live and operate. Traditional ways of doing things are rarely questioned and the tried-and-tested and so-called best practices or current wisdom are applied as the norm. New ways of thinking are viewed as “departing from the norm” and are sometimes welcomed, but usually met with varying degrees of opposition.

Building on the work of Kuhn (1962) on the identification of paradigms as alternative realities, Morgan (1980) views paradigms, metaphors, and puzzle solving as three layers – paradigms as alternative realities, metaphors as bases for schools of thought, and puzzle-solving based on lower-level text and tools. With respect to our teaching of FMs we could map as follows: A paradigm as an alternative reality maps onto the challenge of accepting FMs as a feasible methodology for software development. Current realities in software engineering largely prescribe to the use of semi-formal specification techniques as best practices with the use of FMs being frowned upon. At the metaphorical level the schools of thought typically allow for alternative views, in our case the use of other methodologies, including, of course, FMs. The puzzle-solving level maps onto the lower-level functionalities of the use of FMs – discrete mathematics and logic as shown in Section 3.0. Consequently, ideas from Morgan (1980) are included in our problematisation framework.

6. Problematisation Framework for FMs ODeL

Frameworks may take many forms, e.g., a list of items or a diagram that indicates aspects and associations among these (Mbedzi, 2020). Our problematisation framework for the ODeL of FMs as informed by the discussions in this paper is tabulated in **Table 4**. Cross linking among concepts is indicated by *italicising* the linking concept.

Table 4: Problematisation Framework for the ODeL of FMs.

Aspect	Components	Notes
Conceptual Considerations	Holistic overview of FMs process Learn by heart Agile Cyclic learning Morgan's 3 levels * Paradigms * Metaphors * Puzzle-solving	Students are to gain a *holistic overview* of FMs in software engineering. *Learn by heart* is often practised with long, complicated proofs, e.g., proving the correctness of a while loop though multiple levels.
Notational Complexities	Discrete mathematics Formal logic * Propositional logic * 1st-order predicate logic	Overlap to a large extent with *Verification Complexities*.
Verification Complexities	Specification styles * Algebraic * Process-based * Model-based * Procedural approaches Linking Abstract & Procedural Hidden information * Proof obligations (POs) Pre- & postconditions Software tools Reasoning * Automated, Interactive, Model-checking, * Machine learning Parallel thinking * If-then-else constructs * While loops Industrial-size programs	Many of these aspects relate to face-to-face teaching of FMs in a classroom environment but move into a next level of complexity with ODeL. Uncertainty about the scalability of FMs to industrial size problems link with *FMs Objections*.
Diverse Applications	Non-numeric verification * Management * Strategy * Other applications	These are arguably the most NB for migrating FMs into other, less technical areas.

Aspect	Components	Notes
ODeL Aspects	Hardware aspects * Spreading of physical pages to view spec * Screen size for overview of spec Integrated blended learning * Group visits * Study schools Standards * FMBoK (Formal Methods Body of Knowledge) * Best practices (BPs) Videos * Vodcasts (and podcasts – sound) * Interactivity Social issues * Who's with student/lecturer on the other side * Facial expressions Environments * Moodle * Other environments	For large electronic specs, a large screen is essential. *BPs* to be established. Social aspects may be more NB than appear. The researchers' experiences with MS Teams are that not knowing who besides the person known is on the other side, and lack of first-hand facial expressions all hinder learning. Environments link with, amongst other, *Software tools* and *Reasoning*.
FMs Objections	Complex notations Only for toy problems	Links with scalability of FM and *Diverse Applications*.
FMs Assessment	Standardised environments * Style files and plug-ins Questionnaire to students during course * When to survey and what specifically	Hinting at solutions WRT assessment. Applicable to many areas.
Higher/Cognitive Aspects	Problematisation * Paradigms * Metaphors * Puzzle-solving Social skills to elicit requirements Component-based specification & verification document Developing verification environments	Problematisation links with *Conceptual Considerations*. Elicitation of requirements links at the next development level with, e.g., determining a loop invariant.

7. Theoretical Validation of the Framework

Our framework in **Table 4** gives cognisance of the important aspects around the online teaching of FMs. Various specification styles are indicated, and notational complexities linked to the objections with respect to the steep learning curve of the underlying discrete mathematics and logic have been embedded. Aspects on problematisation that could lead us to a later solution framework are included.

The challenges with ODeL of FMs have been unpacked and summarised appropriately. Of particular importance is acknowledging the challenge with current verification texts, namely the use of numerical-like examples. These are vital for FMs to gain ground in other, non-technical and qualitative application areas. Cognitive aspects elucidated in the literature have been included, as are plug-ins for specialised ODeL environments. Other key aspects are developments around the FMBoK, linked to FMs standards in ODeL. **Table 4** meets our objective stated.

8. Conclusion and Future Work

In this paper we presented challenges with respect to the teaching of FMs in an online environment, specifically ODeL as a niche of a large South African open and distance e-learning institution. Specification complexities with respect to abstract specification and the procedural style were illustrated and additional aspects around formal specification and reasoning were presented. The challenges related to the ODeL of FMs were linked with scholarly literature, likewise with Moodle a sophisticated LMS. Challenges include the absence of specialised environments for verification and reasoning and has led to some institutions having developed their own environments. In defence of Moodle, we note that it is not intended for all possible environments and should in fact not be. As an open-source system it can be tailormade, for example for a FMs environment. On the strength of the FMs for ODeL challenges elucidated, we developed a problematisation framework in the form of Table 4.

Since this paper is on the problematisation of ODeL of FMs, numerous avenues for future work in this area exist. Our framework is conceptual, and more aspects and permutations of the existing ones may be possible. Consequently, a survey among lecturers and postgraduate students in FMs courses could be performed, pre-empted by the necessary ethical clearance approvals. Following these, a comprehensive solution framework could be developed and exercised in higher learning institutions to determine the utility and feasibility thereof.

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9. References

Ackermann, J.G. & van der Poll, J.A. (2020) Reasoning Heuristics for the Theorem-Proving Platform Rodin/Event-B, *The 2020 International Conference on Computational Science and Computational Intelligence (CSCI'20)*, 1, pp. 1800 – 1806, 16 – 18 December 2020, Las Vegas, USA. DOI: 10.1109/CSCI51800.2020.00332.

Alexandru, D., Iftene, A. & Gîfu, D. (2019). Using New Technologies to Learn Programming Languages. In *Information Systems Development: Information Systems Beyond 2020, ISD 2019 Proceedings*, Toulouse, France, August 28-30, 2019, Alena Siarheyeva, Chris Barry, Michael Lang, Henry Linger, and Christoph Schneider (Eds.).

Backhouse, R. (2003). *Program Construction: Calculating Implementations from Specifications*. John Wiley & Sons, ISBN: 0-470-84882-0.

Ban, A-A. & Yusop, N. (2004). Role-playing, group work and other ambitious teaching methods in a large requirements engineering course, 11th IEEE International Conference and Workshop on the Engineering of Computer-Based Systems, pp. 299 - 306. *IEEE Xplore*. DOI: 10.1109/ECBS.2004.1316712

Basile, D., ter Beek, M.H., Fantechi, A., Gnesi, S., Mazzanti, F., Piattino, A., Trentini, D., Ferrari, A. (2018). On the Industrial Uptake of Formal Methods in the Railway Domain. In: Furia C., Winter K. (eds) Integrated Formal Methods. IFM 2018. *Lecture Notes in Computer Science*, 11023. Springer, Cham. https://doi.org/10.1007/978-3-319-98938-9_2.

Bjørner D. & Havelund K. (2014). 40 Years of Formal Methods. In: Jones C., Pihlajasaari P., Sun J. (eds) FM 2014: Formal Methods. FM 2014. Lecture Notes in Computer Science, vol 8442. Springer, Cham. https://doi.org/10.1007/978-3-319-06410-9_4.

Cao, Y., Zhang, S., Chan, M.C.E. & Kang, Y. (2021). Post-pandemic reflections: lessons from Chinese mathematics teachers about online mathematics instruction, *Asia Pacific Education Review*, 22, pp. 157–168. https://doi.org/10.1007/s12564-021-09694-w. Accessed on 1 October 2021.

Chaudhury, B., Varma, A., Keswani, Y., Bhatnagar, Y. & Parikh, S. (2018). *Let's HPC*: A web-based platform to aid parallel, distributed and high-performance computing education, *Journal of Parallel and Distributed Computing*, 118(1), pp. 213-232, ISSN 0743-7315. Available online at: https://doi.org/10.1016/j.jpdc.2018.03.001. Last accessed 15 July 2021.

Cook, C.T., Sun, Y-S. & Sitaraman, M. (2015). Experience report: evolution of a web-integrated software development and verification environment, *Software: Practice and Experience*, 45, pp. 857 – 872.

Dahl, O-J. (1992). Verifiable Programming. Prentice-Hall, Hempstead, Hertfordshire, UK.

Formal Methods Wiki: Projects FMBoK. (n.d.). Available online at: https://formalmethods.wikia.org/wiki/FMBoK. Accessed on 7 August 2021.

Fuller, U., Johnson, C.G., Ahoniemi, T., Cukierman, D., Hernán-Losada, I., Jackova, J., Lahtinen, E., Lewis, T.L., Thompson, D.M., Riedesel, C. & and Thompson, E. (2007). Developing a Computer Science-Specific Learning Taxonomy. *SIGCSE Bulletin*. 39 (4), pp. 152–170. Available online at: https://doi.org/10.1145/1345375.1345438. Accessed on 10 August 2021.

Goguen, J.A., Winkler, T., Meseguer, J., Futatsugi K. & Jouannaud, J.P. (2000). Introducing OBJ. In: Goguen J., Malcolm G. (eds) *Software Engineering with OBJ. Advances in Formal Methods*, vol 2. Springer, Boston, MA. Available online at: https://doi.org/10.1007/978-1-4757-6541-0_1. Last accessed on 5 July 2021.

Guttag, J.V., Horowitz, E. & Musser, D.R. (1978). The design of data type specifications. In Yeh, R.T. (ed), *Current Trends in Programming Methodology*, 4, pp. 414-420.

Ishikawa, F., Yoshioka, N. & Tanabe, Y. (2015). Keys and Roles of Formal Methods Education for Industry: 10 Year Experience with Top SE Program, pp. 35 – 42. National Institute of Informatics, Japan. Available online. Last accessed on 10 August 2021.

Jeppu, N., Jeppu, Y., & Devi, M.K. (2017). Teaching formal methods at undergraduate/graduate level: The three perspectives, in *2017 3rd International Conference on Applied and Theoretical Computing and Communication Technology* (*iCATccT*). IEEE, pp. 310–315.

Joint Task Force on Computing Curricula, Association for Computing Machinery (ACM) and IEEE Computer Society. (2013). Computer Science Curricula 2013: Curriculum Guidelines for Undergraduate Degree Programs in Computer Science. *Association for Computing Machinery*, New York, NY, USA. Available online at: https://doi.org/10.1145/2534860. Accessed on 10 August 2021.

Kourie, D.G. & Watson, B.W. (2012) *The Correctness-by-Construction Approach to Programming*. Springer.

Kuhn, T.S. (1962). The structure of scientific revolutions. *University of Chicago Press*, Chicago.

Mbedzi, M.D. (2020). A decision-making framework to facilitate cost savings and mitigate environmental impacts in the coal mining industry, DBL Thesis, Graduate School of Business Leadership (SBL), Unisa.

Michalikova, A. & Povinsky, M. (2020). Blended Learning as a Way of Teaching in the Pandemic Period, 18th International Conference on Emerging eLearning Technologies and Applications (ICETA), pp. 464-469. DOI: 10.1109/ICETA51985.2020.9379249.

Morgan, G., (1980). Paradigms, metaphors, and puzzle solving in organization theory. *Administrative Science Quarterly*, pp. 605 – 622.

Naidoo, J. & Singh-Pillay, A. (2021). Online Teaching and Learning Within the Context of Covid-19: Exploring the Perceptions of Postgraduate Mathematics Education Students, *Mathematics Education Journals* (*MEJ*), 5(2), pp. 102 – 114. ISSN: 2579-5260 (Online).

Nair, G., Jeppu, Y. & Tahiliani, M. (2020). Teaching EARS to Undergrads in the Pandemic – Industry Academia Experience. 169-174. 10.1109/IBSSC51096.2020.9332163.

Nguyen, B.T., Nguyen, D.M., Tung Ho, L.S. & Dinh, V. (2019). An active learning framework for set inversion, *Knowledge-Based Systems*, 185, 104917. ISSN 0950-7051. Available online at: https://doi.org/10.1016/j.knosys.2019.104917. Accessed on 2 August 2021.

Niculescu, V., Sterca, V. & Bufnea, D. (2020). Agile and cyclic learning in teaching parallel and distributed computing. In *Proceedings of the 2nd ACM SIGSOFT International Workshop on Education through Advanced Software Engineering and Artificial Intelligence* (*EASEAI 2020*). Association for Computing Machinery, New York, NY, USA, 27–33. DOI: https://doi.org/10.1145/3412453.3423198. Accessed of 10 August 2021.

Palshikar, G. (2001). Applying formal specifications to real-world software development. *IEEE Software*, 18, pp. 89-97. DOI: 10.1109/52.965810.

Parnas, D.L. (1998). "Formal methods" technology transfer will fail, *Journal of Systems and Software*, 40(3), pp. 195-198. ISSN 0164-1212, https://doi.org/10.1016/S0164-1212(97)00166-0.

Potter, B., Sinclair, J. & Till, D. (1996). *An Introduction to Formal Specification and Z*, 2nd edition. Prentice-Hall, London, UK.

Rushby, J. (1993). *Formal methods and the certification of critical systems*, 37. SRI International, Computer Science Laboratory.

Saunders, M., Thornhill, A., Lewis, P. (2018). *Research Methods for Business Students*, 8th Edition, London, Pearson.

Stefani, A., Vassiliadis, B. & Xenos, M. (2006). On the quality assessment of advanced e-learning services, *Interactive Technology & Smart Education*, 3, pp. 237-250. Troubador Publishing Ltd.

Van der Poll, J.A. & Dongmo, C. (2012). The Teaching of Operating Systems in a Non-Classroom Environment. *Progressio, South African Journal for open and distance learning practice*, 34(3), pp. 18 – 36, ISSN: 0256-8853.

Van der Poll, J.A. and Dongmo, C. (2013). Formal Methods Tuition in Computing: Bridging the ODeL Challenges. Talk delivered at the CSET 2013 ODL Conference (no full paper exists), 5 – 6 September 2013. Abstract available online at: https://nanopdf.com/download/book-of-abstracts-5ae1a8f6464c8_pdf.

Vescan, A. & Serba, C. (2020). Facilitating Model Checking Learning through Experiential Learning. In Proceedings of the *2nd ACM SIGSOFT International Workshop on Education through Advanced Software Engineering and Artificial Intelligence* (*EASEAI 2020*). ACM, New York, NY, USA, pp. 13–19. DOI: https://doi.org/10.1145/3412453.3423196. Accessed on 1 May 2021.

Woodcock, J. & Davies, J. (1996). *Using Z: Specification, Refinement, and Proof*, Prentice-Hall, London.

Wos, L. (2006). Milestones for automated reasoning with OTTER. *International Journal on Artificial Intelligence Tools*, 15, pp. 3-20. DOI: 10.1142/S0218213006002540.

Relationship between students' self-directed learning and motivation for online learning at undergraduate university level in Mauritius

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Abstract
The recent pandemic has sparked the growth of online learning throughout all levels as never before. It really has generated an enormous incentive for scholarly investigation into teaching strategies. The goal of this study is mainly to determine whether there is a relationship between students' self-directed learning and their motivation for online education. Studying readiness is described as the abilities required by learners to study, with an emphasis on self-directed studies. This study investigates how university graduates stayed inclined to study even through all of the obstacles they faced and overcame throughout the COVID-19 pandemic. As a result, the study was carried in Mauritius, however the potential advantages extend beyond the borders of the country. Data were collected by administering an online questionnaire to 422 students chosen at random who are enrolled in an undergraduate course in the Mauritian universities. The degree of directed learning and desire to study was ascertained using descriptive analysis. To predict the association between students' motivation to learn and their directed learning readiness, a Pearson Correlation test was done. In addition, a regression analysis was performed to assess any impact of the elements of directed learning on learners' motivation in an online learning environment. According to the findings of this study, the learners are motivated and dedicated to their studies. The research revealed a relationship between learners' online learning willingness and motivation. The study results revealed a significant relationship between rising levels of online learning capability and rising levels of learner motivation. Policymakers in charge of Higher Educational Institutions should provide all of the necessary resources for educators to adopt online learning.
Keywords: Higher education, Mauritius, Motivation to learn, Online Learning, and Self-directed learning.

1. Introduction

Covid19 pandemic was a major challenge for all education systems worldwide, including higher education systems. Most governments have had to unexpectedly close their educational institutions to avoid the crowd until additional notice, which caused authorities to urgently prevent students from attending their face-to-face lectures. In order students are not being left unattended during this pandemic period the authorities proposed online studies. Therefore, the conventional method (face-to-face education) was replaced by online learning. The new normal that had become the biggest change in teaching and learning was the online "Learning from home" program. E-learning was the right option to guarantee the continuity of educational activities throughout the Covid-19 pandemic period (Cahyani *et al.,* 2020) which produced a variety of perspectives for academics and students. During the adaptation period, the switch from the usual learning methods to studying online at the beginning of the pandemic was very difficult and burdensome for most academics and students (Guo & Li, 2020). The difficulties occurred because the academics and students were not familiar with the utilization of digital tools in their training and learning activities (Rasmitadila *et al.,* 2020; Basilaia and Kvavadze, 2020). Online learning has provided students with a better alternative to traditional learning, not only because they were comfortable with the technology, but also because they could learn anytime, and anywhere. As a result, learners had an increasing number of choices about when, where, content, and route to study.

Such flexibility forced learners to adapt their engagements regarding the particular education environment (Zimmerman, 2000). Learners were mindful that their educational obligation relied more on themselves rather than their lecturer (Demir, 2015). Therefore, they had to strongly engage in their studies, for instance gaining material, developing and assessing the activities related to their studies. Self-directed learning (SDL) remains as a way to measure students' willingness to learn, protect proper learning, guide intentional behavior, and assess consequent understanding. It is also an approach of lecturing according to the learner's learning ability (Khiat, 2015; Timmins, 2008). Conversely, according to Brockett and Hiemstra (1991) SDL ensues a mixture of the method by which an individual is responsible for his or her own learning, while Houle (1961) claimed that SDL is where a group of learners adopted an independent learning system different from the traditional learning and environment. However, adjustments in the teaching and learning approaches that affect the learning practices of students through the sudden shift to online learning can also influence the motivation of students to study. As a result, this research aims to investigate whether students remain determined to study amid the problems and limitations of online learning. This research seeks to establish whether SDL skills of undergraduate learners and their motivation for online learning differ in accordance with the different universities, gender and study fields.

In particular, the research attempts to look at the instances that undergraduate students studying in the public universities went through during the pandemic, find whether SDL is important, and further explore how SDL keeps the students motivated to learn in an online environment. Understanding their motivations can help in understanding how to help the learners thrive regardless of the various shortcomings and motivate those students facing difficulties to cope with the new learning process.

2. Objectives

This paper attempts to determine how self-study can improve learner motivation for online learning and the core objectives of this study are:

1. To establish whether SDL skills of undergraduate students in an online learning environment differs in accordance with the gender, different universities and study fields.
2. To determine whether the motivation to study online differs in accordance with the gender, different universities and study fields.
3. To ascertain the association between SDL and the motivation to study among undergraduate students.
4. Can the students' SDL abilities significantly predict their motivation to learn?

3. Literature Review

3.1 Online Learning

Several researches have concentrated on the problems related to an introduction of learning online in the higher education environment. Online study is the delivery of virtual education using the help of any such applications as a tool to convey learning (Syarifudin, 2020). Numerous factors have supported to the achievement of online study, namely, the technology used, the characteristics of the teacher, and the characteristics of the students themselves (Pangondian, Santosa and Nugroho, 2019). Implementing online learning is not easy because there are obstacles and shortcomings in its application (Rahman, 2007).

Besides several public HEIs in emerging economies could not get hold of a well-organized Learning Management System (LMS) to facilitate interaction between the learners and their lecturers during the Covid19 pandemic (Sobaih, Hasanein and Abu Elnasr, 2020). Learning online allows students to access their studies at time that is suitable for them. However, the time for students to study at home is longer and they tend to be bored. The habit of students studying together with their friends in class and being explained directly by the lecturer makes one of the obstacles for students adapting to online

learning. The large amount of time at home and the absence of resources and infrastructure to support students' learning activities at home are also obstacles to online learning. The many obstacles encountered in implementing online learning ultimately have an impact on learning motivation. Djamarah (2015) describes that motivation is a variation in the dynamism that is in an individual to do something. The purpose of learning to be successful is related to the motivation of the students (Meidawati *et al.,* 2019). Therefore, students' motivation is needed.

Online learning also depends heavily on the learner's capability to participate actively. In an online environment, the important role of learner's self-regulation, motivation, and active learning inclinations have been emphasized (Chiu & Hew 2018). Though the application of several motivational philosophies to conventional learning settings has been considered as a constructive activity (Lazowski & Hulleman 2016), however, hardly any consideration was given on the application of these conventional motivational philosophies to identify in what way they enhance online study in a technology-infused learning context.

3.2 Self-Directed Learning (SDL)

SDL has been considered important for decades. Deci and Ryan (2000, 2008) have revealed that SDL is an important learning activity, which is individually significant, fascinating, pleasing, and at the same time being self-regulated. A cycle where people consider it to control, organize, ensue and evaluate their education engagements is termed as SDL (Merriam *et al.,* 2007). Hence, the responsibility to accept learning from an independent manner by the learners. To engage in their own learning process, SDL students investigate studying resources, screen their education materials, consider, as well as self-assess them (McLoughlin and Lee, 2010). Learners engagement and participation within the learning system is critical in such a process (Boyer and Usinger, 2015; Grover, 2015). Dawson *et al.* (2012) research showed how innovation and direct learning hold a solid association. The research revealed that innovation additionally improved students' direct learning abilities; similarly, Rashid and Asghar's (2016) research paper demonstrated that there is firm connection between the use of technology and directed learning. Thus, using the internet for learning extensively affects students' motivation in their studies and there are not many researches that has analyzed students' motivation position in SDL from an online learning perspective.

3.3 Motivation

Motivation to study consists of both internal and external support to learners who are studying in order to be able to make amendments in their actions. It plays a major role in learners' learning success. Investigation on learners' learning shows that SDL is greatly associated with the motivation to learn (Law and Breznik, 2017). Hence, motivation is an important element in order to achieve the online learning activities. Motivation indicators in education can be grouped in the following way: 1) want to succeed; 2) support and need to learn; 3) future expectations and goals; 4) pleasure to learn; 5) appealing tasks with regards to learning; and 6) a favorable learning climate. Studies have revealed that learners with learning motivation keep on to perceive studying as crucial, enjoyable as well as appreciate learning exercises (Zimmerman, 2000a, 2000b, 2008). This in turn result in their high educational performance. On the other hand, an absence of motivation happens to be a vital element for low educational performance (Scheel, Madabhushi, and Backhaus, 2009). Concerning the recent pandemic situation, learners' ways to study, their studying techniques, and learning preferences have changed, and that has affected learners' motivation to study in an online learning context. Hence, it has become very important to understand now how SDL influences the motivation of learners to learn in an online environment.

From these theories and assumptions, the following hypotheses were tested:
H1a: Significant variation is present between the learners' SDL abilities and gender
H1b: Significant variation is present between the learners' motivation and gender

H2a: Significant variation is present between the learners' SDL abilities and the universities
H2b: Significant variation is present between the learners' motivation and the universities
H3a: Significant variation is present between the learners' SDL abilities and their field of studies
H3b: Significant variation is present between the learners' motivation and their field of studies
H4: SDL abilities positively correlates with learning motivation in an online learning environment
H5: SDL abilities would positively predict students' motivation for online learning.

4. Methodology

The research utilized a mixed method approach based on an online survey form to deal with the research objectives. A sample of 500 hundred students enrolled in an undergraduate programme within the Mauritian public universities were chosen. Responses were collected from 422 filled up forms representing a response rate of 84.4%. According to Taherdoost (2017) such sample range is regarded adequate to foresee the learning approaches for the above-mentioned population. The questionnaire was filled out on a voluntary basis and no identifying information was captured.

The questionnaire contained both closed-ended questions employed to gather the quantitative data and qualitative questions in the form of open-ended questions. The primary survey items were derived from a review of prevailing literature where the scales were adapted from a survey employed by Bailey and Morais (2005). The questionnaire comprised of 3 sections consisting of closed-ended questions that were supported by a 5-point Likert-type scale as 1 being strongly disagree whereas 5 being strongly agree, additionally to yes/no questions and the open-ended questions that assisted in explaining and interpreting the findings of the quantitative study. The study used a sequential explanatory mixed methods study where an analysis of the quantitative data was conducted first, and then used the qualitative data to interpret those quantitative results. The Statistical Package for the Social Sciences (SPSS) was applied analysed the quantitative results from the questionnaire applying the descriptive statistics, t-tests, ANOVA, Pearson correlation as well as linear regression.

5. Findings

To check for the reliability of the constructs developed in the survey which comprised forty questions, Cronbach Alpha was used. As solicited from Table 1 that the Cronbach Alpha was 0.889 for the current study. This figure is a good figure as several researchers have reiterated that a figure of 0.70 is good. The purpose of Cronbach alpha is to test the relevance of construct items because it shows the internal consistency of the constructs. The 422 students, who completed the survey, represent a response rate of 84.4% and 61.6% were female students whereas 38.4% were male students.

Table 1: Cronbach's Alpha

Cronbach's Alpha	Number of Items
0.889	40

The information of the research was gathered from the undergraduate learners who were studying in the public universities in Mauritius and Table 2 displays the distribution of students.

Table 2: Distribution of Students

Public Universities	Percent
Open University of Mauritius	21.60%
University Des Mascareign	16.60%
University Of Mauritius	28.90%
University of Technology, Mauritius	32.90%

Figure 1 below shows the distribution of the students according to their fields of study. It was observed that out of 422 respondents, 20% were from the Applied Sciences, 33% were from the Engineering field, 5% from the medical field whereas the remaining 42% were from the Social Sciences.

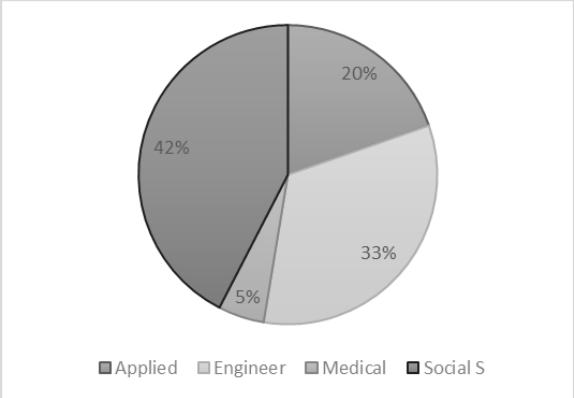

Figure 1: Distribution of the students according to their fields of study

The average values of the variables and their dimensions were computed and listed in Table 3. From the table below, all average scores were considerably beyond the midpoint a score of 2.5. The maximum average score observed was the learning motivation variable (M = 4.1294), whereas the lowermost average score was 3.6327 for online learning (online courses).

Table 3: Means and standard deviations of variables

Variables	Mean	Standard Deviation
Learning Motivation	4.1294	0.47677
Planning and implementing	3.9512	0.55465
Self-Monitoring	3.8441	0.54416
Interpersonal communication	3.8371	0.57147
Online Learning (Learning Materials)	3.8718	0.54843
Online Learning (Online Class)	3.6327	0.55404

Exploring the students' adoption of SDL in an online learning environment, it was noted that 61.37% female students and 38.63% male learners were comfortable with SDL. A sample t-test performed to ascertain whether there existed any disparities when the adopting of SDL between males and females. Gender and self-directed learning are statistically significant, 95% CI, p=0.000 and it was noted that SDL was more engaging to female students (m = 3.97, sd = 0.395) as compared to the male students (m = 3.89, sd = 0.456). However, the variances are close enough to equal. The ANOVA test

was conducted to determine whether gender does influence the SDL abilities of the students. The results obtained suggested that gender does influence the SDL abilities of the undergraduate students ($p < 0.05$). The results is shown in Table 11.

Similarly, the t-test established that gender and motivation are statistically significant, 95% CI, p=0.000 and it was noted that female students were more motivated (m = 3.80, sd = 0.451) compared to male students (m = 3.67, sd = 0.513). An ANOVA test was also performed to show whether motivation differed significantly. It was found gender does influence the motivation to learn among the undergraduate students ($p < 0.05$). The results can be seen in Table 11.

The aim of this study is also to explore if a significant relationship exists amid the universities regarding SDL skills. A cross tabulation was applied to test for significant difference among the universities regarding the students' SDL abilities. Table 4 shows Chi Square Test values between the students studying in the universities and their self-directed learning skills. The test gives a P value of 0.000, since it is below 5%, it therefore indicates that a statistically significant association exists. To know about its degree of association, the Phi and Cramer's V value were also calculated. In the present case, the Phi= 1.401 and Cramer's V = 0.809 showing a very strong and explicit dependence amid the variables examined for larger table.

Table 4: Chi Square Test values between the students studying in the universities and SDL skills

	Value	**Df**	**Asymp. Sig. (2-Sided)**
Pearson Chi-Square	828.505	252	0
Likelihood Ratio	824.351	252	0
N of Valid Cases	422		
Symmetric Measures			
		Value	Approx. Sig.
Nominal by Nominal	Phi	1.401	0
	Cramer's V	0.809	0
N of Valid Cases		422	

Likewise, a cross tabulation was applied to assess the relationship between the universities in terms of motivation for online learning. Table 5 shows the Chi Square Test values between the students studying in the universities and their motivation for online learning. The Chi square test generates a P value that equals to 0.000 specifying that statistically significant association exists amid the universities and the students' motivation for online learning. The Phi and Cramer's V value were also computed for ascertaining possible degree of relationship. Consequently, the Phi= 1.612 and Cramer's V = 0.931 revealing a very strong and positive dependency among the variables examined.

Table 5: Chi Square Test values between the students studying in the universities and their motivation for online learning

	Value	Df	Asymp. Sig. (2-Sided)
Pearson Chi-Square	1096.742	207	0
Likelihood Ratio	1014.021	207	0
N of Valid Cases	422		
Symmetric Measures			
		Value	**Approx. Sig.**
Nominal by Nominal	Phi	1.612	0
	Cramer's V	0.931	0
N of Valid Cases		422	

Subsequently, whether the SDL vary based on the field of study was investigated by way of a Pearson's Chi- square Test enhanced through the effects of Cramer's V Coefficient and Phi coefficient. From the outcomes described within Table 6 below, it is concluded that there is statistical reliance amid the two variables explored, as the test value was equivalent to 0.000. Similarly, whether the motivation for online learning vary based on the field of study was investigated through Pearson's Chi-square Test, Cramer's V, and Phi coefficients. From the outcomes presented in Table 7 where the Chi-square value = 0.000, Cramer's V = 1.587, and Phi = 0.916) it can establish that statistically significant and intense dependency amid the variables explored, indicating that the field of study of the students holds a statistically significant and robust influence on their motivation for online learning.

Table 6: Chi Square Test values between SDL and the field of study

	Value	Df	Asymp. Sig. (2-Sided)
Pearson Chi-Square	862.557	252	0
Likelihood Ratio	716.656	252	0
N of Valid Cases	422		
Symmetric Measures			
		Value	**Approx. Sig.**
Nominal by Nominal	Phi	1.43	0
	Cramer's V	0.825	0
N of Valid Cases		422	

Table 7: Chi Square Test values between motivation for online learning and the field of study

	Value	Df	Asymp. Sig. (2-Sided)
Pearson Chi-Square	1062.494	207	0
Likelihood Ratio	916.444	207	0
N of Valid Cases	422		
Symmetric Measures			
		Value	**Approx. Sig.**
Nominal by Nominal	Phi	1.587	0
	Cramer's V	0.916	0
N of Valid Cases		422	

To predict the association between SDL and motivation to learn in an online learning environment, the Pearson Correlation test was conducted. It is observed from Table 8 that is a high degree and positive correlation between SDL and motivation, which was statistically significant (r = .593, p = .000). Consequently, it is established that there is correlation between studied variables.

Table 8: Correlation between self-directed learning and motivation to learn in an online learning environment

Variable	N	R	Sig.
Self-Directed Learning	422	.593**	0
Motivation	422		

**Correlation is significant at the 0.01 level (2-tailed)

A liaison amid SDL and students' online learning motivation was investigated using linear regression analysis as shown in Table 9 below. The p-value was calculated using regression analysis, which drew a P value resulting in 0.000 that is below the significance point of 5%. Therefore, the linear regression model showing a significant association between SDL and online study success motivation.

Table 9: Coefficients of regression model showing association between SDL and motivation for online learning

Variable	R	R^2	R^2adj	Std err	T value	P value
Self-Directed Learning (SDL)	0.593	0.351	0.35	0.387	15.076	0

Since it has been established that SDL and motivation for online learning have a positive relationship, it became important to test the association between components of SDL and motivation for online learning. Table 9 showed a significant linear regression model which revealed that SDL abilities positively predict students' motivation for learning in an online environment.

Table 10: Coefficients of regression model and variance analysis of the association among elements of SDL and motivation for online learning

Source of changes	Sum of sqrs	df	Mean sqrs	R	R^2	R^2adj	F value	Sig.
Regression	34.989	4	8.747	0.601	0.362	0.355	59.032	0.000
Residual	61.791	417	0.148					
Total	96.781	421						
Variable			B	Std. Error		Beta	t	Sig.
(Constant)			1.173	0.184		-	6.366	0
Learning in general			0.118	0.048		0.117	2.458	0.014
Planning & implementing			0.187	0.045		0.217	4.179	0.000
Self-Monitoring			0.265	0.049		0.300	5.366	0.000
Communication			0.088	0.04		0.105	2.175	0.030

From Table 10, it can be noted that the components of SDL have a significance level less than 0.05, it proved that the components of SDL (learning in general, planning & implementing, self-monitoring, and communication) significantly predict the motivation of students for online learning. Therefore, the most important predictors of motivation are planning & implementing and self-monitoring (Table 10). This suggested that a significant association among the elements of self-study and students' motivation for online learning.

6. Discussion

The aim of this research is to explore how undergraduate learners' SDL abilities and motivations change when learning online. This research also explored the relationship between SDL and learning motivation of undergraduate university students in an online learning environment.

Table 11: Hypotheses testing results

Hypotheses	P-Value	Decision
H1a: Significant variation is present between the learners' SDL abilities and gender	0.047	Accept
H1b: Significant variation is present between the learners' motivation and gender	0.005	Accept
H2a: Significant variation is present between the learners' SDL abilities and the universities	0.000	Accept
H2b: Significant variation is present between the learners' motivation and the universities	0.000	Accept
H3a: Significant variation is present between the learners' SDL abilities and their field of studies	0.000	Accept
H3b: Significant variation is present between the learners' motivation and their field of studies	0.000	Accept
H4: SDL abilities positively correlates with learning motivation in an online learning environment	0.000	Accept
H5: SDL abilities would positively predict students' motivation for online learning.	0.000	Accept

While analyzing SDL according to gender, it was found that there is a substantial difference in SDL ability between female and male learners. Consequently, it was found that female learners had considerably higher SDL ability than their male counterparts did. Saban's (2008) also showed that

female students had greater levels of intellectual awareness as well as stimulation as compared to their male colleagues. The literature also includes other studies showing that women are more capable of independent learning (Swart, 2018; Slater *et al.,* 2017; Hutto 2009; Guglielmino *et al.,* 1987). Likewise, it can often be said that learners have a high level of motivation, are interested with self-development, and therefore intend to maintain their learning. Higher education is designed to enable individuals to advance in their field and have deep knowledge in that field to keep learning and grow themselves; these qualities may be enhancing their need for higher training as a procedure for academic as well as professional advancement. Saracaloglu (2008) concludes that graduate students are motivated to study at an academically 'appropriate' level.

Students' SDL skills and motivation are significantly affected by the universities where they are studying. The institutions practices helped to develop their students' SDL skills, which in turn motivated them to study online. The additional variable studied in the research paper was study fields. While students' SDL skills results were examined pertaining to study fields, the lowermost total went to Medical students subsequently having Applied Sciences and then Engineering students. Hence, study field having the uppermost SDL skills results was Social Sciences. Students' SDL skills diverged considerably according to their study fields. Prior studies also showed higher scores for SDL among Social Sciences students (Kozikoglu, 2014; Yaman, 2014).

Both the qualitative and quantitative findings of this study illustrate that a significant relationship exists between the motivation of self-study and online learning of undergraduate students studying at Mauritius public TEI. The result indicates that students at selected public universities are highly motivated and willing to learn in an online learning environment. Students will always meet the requirements if they are motivated to study and are probably interested in engaging in self-study to acquire the education and abilities needed to pass a module. As Guglielmino *et al.* (2005) cites, learners with high self-direction are autonomous as well as focus on education. They are responsible for their learning and regards the issues as a challenge, not a disability. They are self-controlled with a high level of curiosity. They are actors with a strong tendency to change and are certain, innovative and able to apply basic learning skills. Thus, SDL abilities positively predict students' motivation for learning in an online environment, which means that students with strong SDL abilities would be more motivated to learn in an online learning environment and compared to those learners who have poor SDL abilities.

7. Conclusion

The results of this study, first of all, show a positive and significant relationship existing between the undergraduate students' SDL and motivation. Second, the results of the study revealed that in an online learning environment the female learners were having considerably higher SDL abilities and motivation to study as compared to male students. In addition, it would be valuable to create more activities that would develop the students' SDL abilities for the undergraduate students. By incorporating such activities, this may improve academic performance, as the students will be motivated to learn. For realizing higher SDL skills among undergraduate students, their views need to be considered and the learners should recognize their learning needs while designing the learning objectives in the various fields of study. Universities need to devise different learning approaches in order to encourage students to observe and assess their own learning. Ideally, the results of this research will help expand the scope of knowledge and enhance the understanding of online learning in terms of stimulus and SDL in the Mauritian Higher Education environment. Further studies can be conducted to understand whether SDL influences the motivation to learn, which in turn positively predicts high educational performance of learners in an online environment.

8. References

Bailey, K. D., and Morais, D. B. (2005). Exploring the use of blended learning in tourism education. Journal of Teaching in Travel & Tourism, 4(4), 23-36.

Basilaia, G., and Kvavadze, D. (2020). Transition to Online Education in Schools during a SARS-CoV-2 Coronavirus (COVID-19) Pandemic in Georgia. *Pedagogical Research*. https://doi.org/10.29333/pr/7937

Boyer, N. R., and Usinger, P. (2015). Tracking pathways to success: triangulating learning success factors. Int. J. Self-Directed Learn. 12, 22–48.

Brockett, R.G. and Hiemstra R. (1991). Self-Direction in Adult Learning: Perspectives on Theory, Research, and Practice. London and New York: Routledge

Cahyani, A., Listiana, I. D., and Larasati, S. P. D. (2020). Motivasi Belajar Siswa SMA pada Pembelajaran Daring di Masa Pandemi Covid-19. *IQ (Ilmu Al-Qur'an): Jurnal Pendidikan Islam*. https://doi.org/10.37542/iq.v3i01.57

Chiu, T. K., and Hew, T. K. (2018). Factors influencing peer learning and performance in MOOC asynchronous online discussion forum. *Australasian Journal of Educational Technology*, *34*(4). https://doi.org/10.14742/ajet.3240

Dawson, S., Macfadyen, L., Risko, F., Foulsham, T. and Kingstone, A. (2012). Using technology to encourage self-directed learning: The Collaborative lecture annotation system (CLAS). *Ascilite 2012: Future Challenges, Sustainable Futures*, 246-255.

Demir, O. (2015). The investigation of e-learning readiness of students and faculty members: Hacettepe University Faculty of Education example [Master Thesis]. Ankara: Hacettepe University.

Djamarah, S. B. (2015). Psikologi Belajar. Jakarta: PT. Rineka Cipta.

Grover, K. (2015). Online social networks and the self-directed learning experience during a health crisis. Int. J. Self Direct. Learn. 12, 1–15.

Guglielmino, L. M., Asper, D. A, II, Findley, B. W., Lunceford, C. R., McVey, R. S., Payne, S. M. et al. (2005). Common barriers, interrupters and restarters in the learning projects of highly self-directed adult learners. [Electronic Version]. International Journal of Self-Directed Learning, 2(1), 71-93.

Guglielmino, P. J., Guglielmino, L. M., and Long, H. B. (1987). Self-directed learning readiness and performance in the workplace-implications for business, industry and higher education. High. Educ. 16, 303–317. doi: 10.1007/BF00148972

Guo, B., and Li, H. (2020). Guidance Strategies for Online Teaching during the COVID-19 Epidemic: A Case Study of the Teaching Practice of Xinhui Shangya School in Guangdong, China. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3565627

Houle, C. O. (1961). *The inquiring mind: A study of the adult who continues to learn*. University of Wisconsin Press, Madison, WI. https://doi.org/10.1016/j.nepr.2008.02.004

Hutto, S. T. (2009). The Relationships of Learning Style Balance and Learning Dimensions to Self-Directed Learning Propensity among Adult Learners.

Khiat, H. (2015). Academic performance and the practice of self-directed learning: The adult student perspective. *Journal of Further and Higher Education*, *9486*(October), 1–16. https://doi.org/10.1080/0309877X.2015.1062849

Kozikoglu, I. (2014). Analysis of university and vocational school students' lifelong learning competences. J. Instruc. Technol. Teach. Educ. 3, 29–43.

Law, K. M., and Breznik, K. (2017). Impacts of innovativeness and attitude on entrepreneurial intention: Among engineering and non-engineering students. International Journal of Technology and Design Education, 27(4), 683–700.

Lazowski, R.A. and Hulleman, C.S. (2016). Motivation interventions in education: A meta-analytic review. Review of Educational Research, 86(2): 602-640.

McLoughlin, C., & Lee, M. J. W. (2010). Personalised and self-regulated learning in the Web 2.0 era: International exemplars of innovative pedagogy using social software. *Australasian Journal of Educational Technology, 26*, 28–43.

Meidawati, M., Sobron, A., and Bayu, R. (2019). Persepsi Siswa dalam Studi Pengaruh Daring Learning Terhadap Minat Belajar IPA. SCAFFOLDING: Jurnal Pendidikan Islam dan Multikulturalisme, 1(2), 30–38. doi:10.37680/scaffolding.v1i2.117

Merriam, S. B., Caffarella, R. S., and Baumgartner, L. M. (2007). Learning in Adulthood. San Francisco, CA: Jossey-Bass.

Pangondian, A., Santosa, I., and Nugroho, E. (2019). Faktor- Faktor yang Mempengaruhi Kesuksesan Pembelajaran Daring dalam Revolusi Industri 4.0. In Prosiding seminar nasional teknologi komputer & sains.

Rahman, U. (2007). Mengenal Burnout pada Guru. Lentera Pendidikan : Jurnal Ilmu Tarbiyah dan Keguruan, 10(2), 216–227. doi:10.24252/lp.2007v10n2a7

Rashid, T. & Asghar, H. M. (2016). Technology use, self-directed learning, student engagement and academic performance: Examining the interrelations. *Computers in Human Behavior, 63*, 604-612.

Rasmitadila, Aliyyah, R. R., Rachmadtullah, R., Samsudin, A., Syaodih, E., Nurtanto, M., and Tambunan, A. R. S. (2020). The perceptions of primary school teachers of online learning during the covid-19 pandemic period: A case study in Indonesia.

Ryan, R. M., and Deci, E. L. (2000, 2008). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. American Psychologist, 55, 68-78.

Saban, A. I. (2008). An investigation of elementary school teaching department students' metacognition awareness and motivation in terms of some sociodemographic variables. Ege Egitim Dergisi 9, 35–58.

Saracaloglu, A. S. (2008). The relationship between post graduate students' academic motivation level, research anxiety and attitudes with their research competence. Yüzüncü Yil Univ. Faculty Educ. J. 5, 179–208.

Scheel, M. J., Madabhushi, S., and Backhaus, A. (2009). The academic motivation of at-risk students in a counseling prevention program. *The Counseling Psychologist, 37*(8), 1147–1178. https://doi.org/10.1177/0011000009338495

Slater, C. E., Cusick, A., and Louie, J. C. Y. (2017). Explaining variance in self-directed learning readiness of first year students in health professional programs. BMC Med. Educ. 17:207. doi: 10.1186/s12909-017-1043-8

Sobaih, A. E. E., Hasanein, A. M., and Abu Elnasr, A. E. (2020). Responses to COVID-19 in Higher Education: Social Media Usage for Sustaining Formal Academic Communication in Developing Countries. *Sustainability, 12*(16), 6520. https://doi. org/10.3390/su12166520

Swart, A. J. (2018). Self-directed learning - fashionable among all first-year African engineering students? Cent. Univ. Technol. 20, 15–22.

Syarifudin, A. S. (2020). Impelementasi Pembelajaran Daring untuk Meningkatkan Mutu Pendidikan Sebagai Dampak Diterapkannya Social Distancing. Jurnal Pendidikan Bahasa dan Sastra Indonesia Metalingua,5(1), 31–34. doi:10.21107/metalingua.v5i1.7072

Taherdoost, H. (2017). Determining sample size: How to calculate survey sample size. *International Journal of Economics and Management Systems, 2*, 237-239.

Timmins, F. (2008). Take time to facilitate self-directed learning. *Nursing Education Practice, 8*(5). Unpublished doctor of philosophy thesis. The University of Southern Mississippi, Mississippi.

Yaman, F. (2014). Investigating of Life Long Learning Tendency of Teachers (The Example of Diyarbakir). Unpublished Master Thesis. Dicle University, Institute of Educational Sciences, Diyarbakir.

Zimmerman, B. J. (2000). Attaining self-regulation: A social-cognitive perspective. In M. Boekaerts, P. R. Pintrich, and M. Zeidner (Eds.), Handbook of self-regulation, (pp. 13–39). San Diego: Academic.

Zimmerman, B. J. (2000a). Attaining Self-Regulation. In Handbook of Self-Regulation (pp. 13–39). Elsevier. https://doi.org/10.1016/B978-012109890-2/50031-7.

Zimmerman, B. J. (2000b). Self-Efficacy: An Essential Motive to Learn. *Contemporary Educational Psychology*. https://doi.org/10.1006/ceps.1999.1016

Zimmerman, B. J. (2008). Investigating self-regulation and motivation: Historical background, methodological developments, and future prospects. *American Educational Research Journal, 45*(1), 166–183. https://doi.org/10.3102/ 0002831207312909

Virtual reality education: A potential catalyst to the next stage of the evolving pedagogy

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Abstract
Teaching and learning are often still based on a traditional education mentality: children must learn while sitting behind a desk, with learning material limited to textbooks and a ridged syllabus set out by governmental institutions (Tularam & Machisella, 2018). The COVID-19 pandemic, however, forced educational institutions to utilise technology to be able to continue with education.
This study aims to challenge the current traditional education approach by determining if the implementation of virtual reality into educational practices within schooling systems have the potential to alleviate the static conventional teaching and learning methods.
The researchers adopted a qualitative research method to analyse whether the implementation of virtual reality within the education system could be beneficial. A virtual reality education prototype was created to present the photosynthesis process in an interactive manner. Learners (aged between 10 and 13) would immerse themselves into this virtual environment, interact with the objects, and complete tasks about the photosynthesis process.
The evaluation involved an initial expert review, followed by a usability test where representatives from the target population participated. The results of the usability study were incredibly positive and revealed that the participants thoroughly enjoyed the learning experience. Although they did quite well in the assessment part, the problems that they encountered could be attributed to needing more time to get familiar with the environment.
The results indicate that virtual reality within education systems have the potential to empower learners to take control over their education and shape understanding through experiences.
Keywords: Virtual reality; VR Education; Teaching and Learning; Holistic education; Active learning

1. Introduction

It is apparent that the poor basic education system in South Africa has harmed our economy (Mtantato, 2018). If the education system continues to deteriorate at this rate, future South Africans will remain stagnant and lack the expertise and knowledge needed to survive in the future technological global economy.

Therefore, learners (the term generally used to refer to school-going children in the South African context) are still deprived of the education needed to set a stable foundation for their future (Amnesty International, 2020). It has been stated that virtual reality has the power to improve how learning concepts are taught to learners and allows them to experience and take charge of their education (VIAR, n.d.).

This article investigates whether the use of emerging techniques and technologies, particularly virtual reality, have the potential to alleviate the current issues within teaching and learning practices.

2. Problem Statement

The crumbling South African education system has failed their children, thus giving rise to the need for a new method of teaching and learning (Amnesty International, 2020). According to Cicekci and Sadik (2019), teachers are unable to keep learners' attention for long periods of time while learners have difficulty in comprehending the work that is being taught. The current education system does not accommodate a child's dynamic learning abilities and promotes the belief that the only ticket to

success is based on the grades you achieve at school (Boyce, 2019). As the traditional education system is gradually becoming obsolete (Adams, 2021), there is a need to investigate new techniques or technologies that could be used to reform the current education system.

3. Research Aims and Objectives

This article aims to determine whether the use of emerging techniques and technologies, particularly virtual reality, has the potential to alleviate current issues present within teaching and learning practices.

Expert reviews and usability studies were used in the evaluation of a newly created virtual reality education prototype. The researchers investigated whether the results of these evaluations would indicate if there were potential for virtual reality to be incorporated into the primary education system in South Africa.

4. Problem Statement

To determine whether the use of emerging techniques and technologies, particularly virtual reality, has the potential to alleviate current issues present within teaching and learning practices as mentioned above, this research study attempted to answer the following research question:
How can virtual reality be incorporated as an additional teaching and learning tool in primary education in South Africa?

5. Brief Review of Literature

5.1 Introduction

While the shadow of the COVID-19 pandemic continues to loom over the planet, education systems have slowly adapted to the idea of online education. The potential for online education has accelerated the opportunities for new techniques and technologies to be implemented alongside these online education practices. Virtual reality, for example, offers learners access to a variety of educational experiences and knowledge, thus eliminating factors that would have hindered their ability to access these information sources (Hassan, 2021).

5.2 Virtual Reality and Virtual environments

Although the terms virtual reality and virtual environments are used interchangeably, there is a minor difference between the two. Virtual reality is the state of experiencing something comparable to reality, with this “something” being a virtual environment (Eisenberg, n.d.). A virtual environment is an artificial space in which users are immersed and can navigate and interact with objects within this simulated environment (Stachoň, Kubicek & Herman, 2020).

5.3 Role of Education in Technology

Education is no longer bound to a classroom; the internet and electronic devices have made online education possible for people from all walks of life with a passion to learn. Information Technology allows people to learn in a more dynamic manner instead of being bound to the outdated pen-and-paper way of learning (Sutherland, 2020).

According to Dale’s Cone of Experience (Dale, 1969), people retain information more effectively through what they “do” than through what they have heard, read, or seen. The Multimedia Cone of Abstraction (Baukal, Ausburn & Ausburn, 2013) was proposed as an updated version of Dale’s Cone of Experience (Dale, 1969), due to the growing inclusion of multimedia within the learning context. As seen in Figure 1, virtual reality occupies the bottom section of the cone, while symbols occupy the top. The use of a cone in both designs suggests that concepts occupying the bottom section of the cone have the likelihood of being more effective learning techniques for more learners in comparison to the top section, where fewer learners have the ability of processing information in these formats.

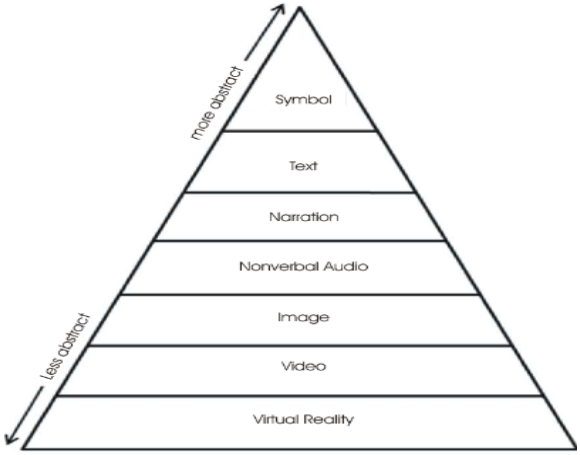

Figure 6: Multimedia Cone of Abstraction

5.3.1 Benefits of Using VR as an Educational Tool

Education systems across the world have created boundaries of how learners should learn. These systems put pressure on learners to conform to a traditional learning system where they are required to keep up with an inflexible schedule filled with copious amounts of work, taught in a classroom environment by one teacher (Ross, 2015).

Virtual reality facilitates an interactive learning environment that can provide learners with the ability to generate their understanding and solve problems with the additional advantage of experiencing learning in a virtual world (Roussou, 2001). The researchers believe virtual reality could assist in bringing education closer to reality by allowing learners to experience the learning material in a hands-on manner.

5.4 Evolution of Teaching and Learning in South Africa

Over time, teaching and learning have undergone a significant evolution from paper-based learning to online education. Yet paper-based learning is still a primary element in the existing South African educational system (PRESS OFFICE: Nashua, 2016).

This section will discuss the various forms in which education can be presented, namely traditional, online, and virtual.

5.4.1 Traditional Education

Currently, in South Africa, learners are still taught using textbooks, a form of paper-based learning, and teachers try to implement videos and group activities to help learners feel more engaged during the lesson. This face-to-face learning requires learners to receive information passively from the teacher and this information is internalised through memorisation (Davis, 2021).

Although this type of lesson promotes interaction between learners, they may lose interest due to the lack of active learning which, in turn, can lead to a decrease in the ability to comprehend and understand information (Katharina, n.d.) .

5.4.2 Online Education

There are countless games available online that can be used as learning tools in classrooms to additionally promote digital literacy. This computer-based teaching method promotes active learning within children. Active learning promotes higher-order thinking within learners, thus promoting

critical thinking, and encouraging interaction between learners, teachers, and the learning material (Asok, Abirami, Angeline & Lavanya, 2016).

5.4.3 Virtual Reality Education

In South Africa, the implementation of virtual reality in learners' education is still in its infancy. This computer-based teaching method promotes digital literacy, active learning and encourages holistic education rather than traditional education. Therefore, virtual reality has the potential to catalyse the next stage of the evolving pedagogy (Reily, 2016).

5.4.4 Comparison of Existing Work and the Prototype

In Table 1, a comparison is made between the different forms of teaching, namely traditional, online, virtual reality and the prototype discussed in this article. The prototype implements various aspects of the existing work to promote an evolution rather than a revolution of the current pedagogy.

Table 5: Existing work (Caroline, 2021; LSU Online, 2020) vs. the prototype

Feature	Traditional Education	Online Education	Virtual Reality Education	Prototype
Paper-based	X			
Computer-based		X	X	X
Active learning		X	X	X
Passive learning	X			
Holistic education			X	X
Self-paced		X	X	X
Face-to-face learning	X			
Requires a classroom environment	X			
Learn through experience			X	X
Caters for individual learning abilities			X	X
Promotes learning through memorisation	X			
Promotes learning through understanding		X	X	X
Activates higher-order learning		X	X	X
Promotes digital literacy		X	X	X

5.5 Teaching and Learning with Virtual Reality in South Africa

The researchers believe that when considering learning and development aspects, implementation of virtual reality technology in primary education institutions would be a suitable area to invest in. Virtual reality is highly beneficial for developing countries, such as South Africa, because it provides a diverse digital learning solution that could potentially amend the inequality gap present in the South African education system (eiffelcorp, 2018).

Through the assessment of literature, the researchers believe that the potential for virtual reality in contributing to the evolving pedagogy is commendable. To critically assess this potential, a virtual reality education prototype, with its focus on the photosynthesis process, was created and evaluated by a target population. According to Dimec and Strgar (2017), the process of photosynthesis is a fundamentally important process on Earth, thus making it an important subject matter to be included in curricula across the world. Therefore, the researchers decided that this would be an appropriate topic for a virtual lesson.

6. Research Design and Methodology

To analyse and evaluate the potential for virtual reality in the South African education system, prototyping was chosen as the research design. This involves the creation of a model that contains enough functionality to test a concept and develop detailed feedback of the model before the implementation of the finished product (Simpson, 2016). An agile methodology was adopted in creating a prototype.

A brief explanation of the agile methodology, its application, as well as a summary of the prototype, named Scienceville, and evaluation methods used to test the prototype, are discussed in the following sub-sections.

6.1 Agile Technology

According to Sacolic (2020), agile development focuses on the division of a problem into smaller tasks and the users of the system are prioritised over technology.

The researchers believed that dividing each concept of the lesson into smaller tasks was an efficient way of creating the prototype. The users of the target population were additionally involved in the ongoing iterative creation of the prototype. Throughout the creation of the prototype, express testing was performed, but as each concept was completed, an individual from the target population was asked to test the concept. Adaptations were then made based on the test results.

6.2 Virtual Reality Prototype: Scienceville

In this section, more details are provided regarding the virtual reality prototype with a specific focus on the technology used, the theme, and the photosynthesis lesson.

6.2.1 Technology Used

The virtual lesson was created on Unity Engine and the Oculus Rift (see Figure 2) was the virtual reality device that was used to immerse individuals into the virtual environment.

Figure 7: Oculus rift *(Oculus, n.d.)*

6.2.2 Theme

According to White (2016), designing games for children can be quite challenging. The reason for this is that the designers are adults and not children anymore. The researchers opted for a prototype that has a “cartoony” style. Support for the use of a cartoon-like style was provided by the prominent use of cartoon characters in the "Thunderbolt Kids: Natural Sciences and Technology" textbook (Siyavula, n.d). This is one of the recommended textbooks that were developed according to the South African Curriculum and Assessment Policy Statement (CAPS) syllabus for Grade 6 learners.

6.2.3 Photosynthesis Lesson

The virtual lesson consisted of four main concepts, namely water, sunlight, carbon dioxide, and the photosynthesis equation. Learners would immerse into the virtual garden where they would have to complete a series of tasks pertaining to the photosynthesis process.

Task 1: Watering the plant

Once immersed into the environment, the learner is greeted by virtual characters who provide instructions on the task that needs to be completed, as seen in Figure 3.

Figure 8: Water

The first task is for the learner to water the virtual plant. Once this is completed and the necessary information is read, a prompt to the next task will appear.

Task 2: Sunlight

The next task (see Figure 4) is to catch the sunlight elements from above and place them onto the chlorophyll characters that can be found on the leaf of the plant.

Figure 9: Sunlight

Task 3: Carbon dioxide

This task requires the learner to grab the carbon dioxide particles in the air and place them inside the stomata that can be found on top of the leaf, as can be seen in Figure 5.

Figure 10: Carbon Dioxide

Task 4: Photosynthesis equation

The final task (see Figure 6) requires the learner to consolidate all the information he/she had gained from the first three tasks to help him/her complete the photosynthesis equation. By successful completion of this task, the learner will reach the end of the photosynthesis lesson.

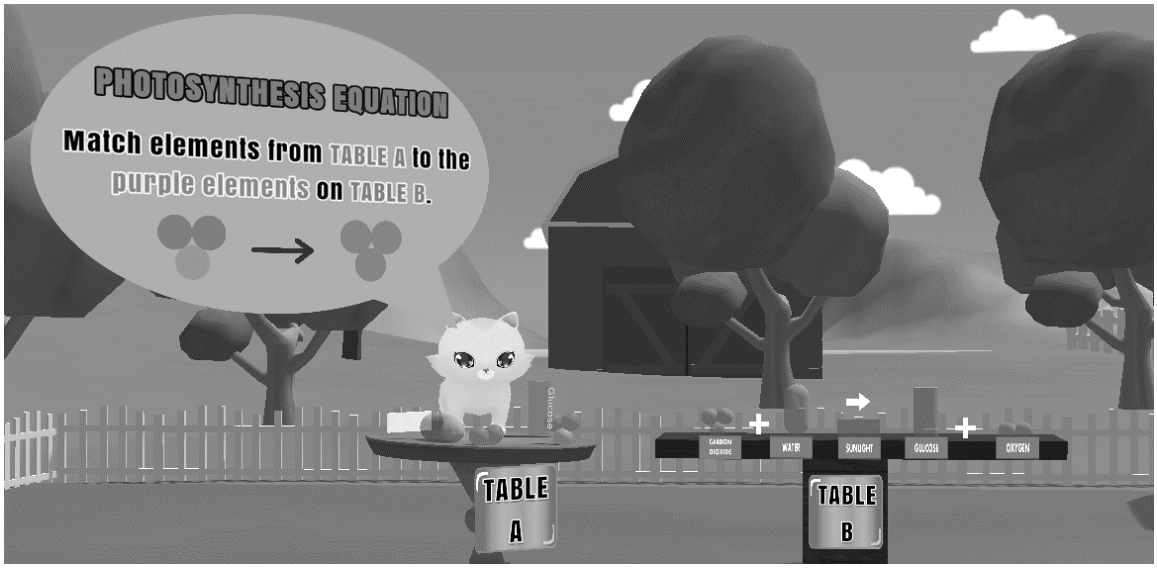

Figure 11: Photosynthesis equation

6.3 Evaluation of Prototype

Throughout the prototype lifecycle, different evaluation methods were employed, such as an expert review and usability test, to ensure that the finished product embodied the learners' educational needs.

6.3.1 Evaluation Methods

6.3.1.1 Expert Review

Two experts from the researchers' affiliated institution were asked to evaluate the prototype and identify issues that would need to be addressed. The one expert is an HCI researcher while the other specialises in the field of educational technology. The experts were asked to apply the think-aloud protocol. This implied verbalising their thoughts as they used the system and moved through the different interfaces (Nielsen, 2012).

The evaluation was conducted in the post-graduate computer laboratory where all COVID-19 regulations were adhered to. The Oculus Rift and its accessories were sanitised before and after use. The test facilitator (one of the researchers that acted as moderator), and experts were required to wear masks and sit two meters apart throughout the evaluation process. Analysis of the expert review results is discussed in Section 4.

6.3.1.2 Usability Test

Once the relevant adaptations were made, a usability test was conducted on the finished prototype.

Recruitment Criteria

Since this system was designed for children, the following criteria were used for recruiting the participants in the evaluation of the prototype:

- Participants between the ages of 10 to 13 years old.
- Participants who had some sort of computer experience.
- Participants who enjoyed playing computer games.
- Participants with little or no knowledge of the photosynthesis process.

7. Sampling Method and Sample Size

According to Etikan (2016), convenience sampling is a haphazard method of sampling where samples of the target population are selected according to their availability regarding their accessibility and willingness to partake in a research study. Due to the safety precautions necessitated by the COVID-19 pandemic, the researchers believed that a convenience sampling method would be the best option to recruit participants.

It was important for the researchers to ensure that the participants were willing to participate and that parental or guardian consent was obtained before the testing and evaluation of the prototype would commence. The parents or guardians were informed of all the safety precautions and cleaning methods that would be in place to keep each participant safe. It was additionally made clear that the participants and/or their parents and guardians were more than welcome to decline participation. A total of eleven participants were available to take part in the usability test.

8. Test Protocol

To allow the test facilitator to clean and sanitise the testing area before and after each test, each participant was given a specific day to test the system. Therefore, the testing of the system prototype was spread across eleven days.

During each testing session, the participants were given 4 tasks to perform, as outlined in Section 6.2.3. The task success metric was based on the successful completion of each task, while the task time metric was determined by the duration of the successful completion of each task (or the time until the participant gave up on the task).

The expectation measure (Albert & Dixon, 2003) was employed during the usability test to determine how easy/difficult each task was (called the expectation measure) in comparison to how easy/difficult the participant thought it was going to be (called the expectation measure). For each task, an average expectation rating and an average experience rating can be calculated. The results for the two scores are then visualised as a scatterplot.

While the participants were testing the prototype, they were also asked to think-aloud. After completing the testing, participants were asked to answer a paper-based multiple-choice assessment. The assessment consisted of 7 multiple-choice questions, each about the tasks that they had to complete. Questions such as what the photosynthesis process is, what is carbon dioxide made up of and selecting the correct equation for the photosynthesis process were asked. These questions required participants to reflect on their interactive experience to help them determine the answers. Lastly, the participants had to rate their virtual reality experience and provide additional comments or thoughts on this “new” learning method.

9.0 Analysis and Discussion of Results

In analysing and discussing the findings of the evaluation, the results of the expert review will first be discussed, followed by the results of the usability test.

9.1 Expert Review Results

The experts provided suggestions on how to improve the interface and the different tasks presented by the prototype.

The following summarises the expert feedback:

- Addition of haptic feedback throughout the tasks to provide the learner with non-visual cues of interaction.

- Consistency in colours enables the learner to associate certain aspects of the lesson to a specific colour.
- Before the learner proceeds with the virtual lesson, there should be an instruction scene that explains how each controller of the Oculus Rift should be used.

  Since the users of the prototype will be children, the experts reiterated the importance of keeping the tasks simple and child friendly. The goal of the prototype is to contribute to how children learn and keeping that in mind throughout the development and enhancements of the system, was very important.

9.2 Usability Test Results

The usability test results will be discussed in terms of task success, time per task, the assessment results, and the results of the expectation measure.

9.2.1 Task Success

Task success measures the percentage of participants who were able to complete each task for a study (Nielsen & Budiu, 2021). In Figure 7, we see that with tasks 1 (watering the plant) and 3 (providing carbon dioxide), participants were able to complete the tasks with no problem, or they had a minor problem but could figure out on their own what needed to be done to complete the task. However, a few participants had major problems (major being defined as needing the assistance of the moderator) with task 2 (adding sunlight) and task 4 (creating the photosynthesis equation).

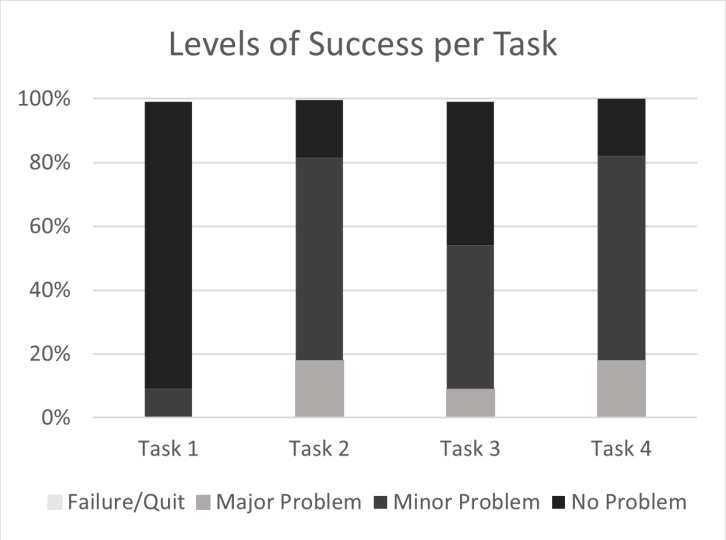

Figure 12: Levels of Success per Task

9.2.2 Time per Task

The time that it took for each participant to complete each of the tasks was measured in seconds. Most of the participants completed each task within the mean time range, with one or two outliers in task 2 (adding sunlight) and task 4 (creating the photosynthesis equation) (see Figure 8). These outliers coincide with the task success data in Figure 7, where there were a few participants who required some help from the moderator to complete the task.

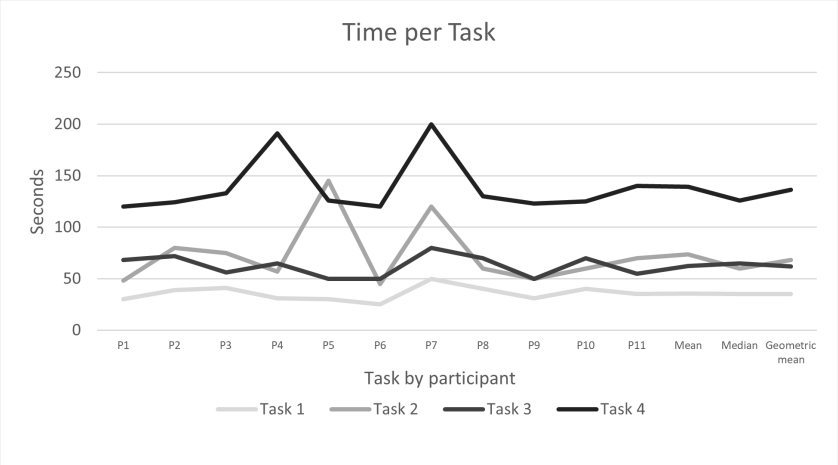

Figure 13: Time per Task

9.2.3 Assessment Marks and Overall Rating

Once the participants had completed the virtual lesson, they were required to complete an assessment to test their knowledge of the content of the lesson. Additionally, they were required to rate their virtual reality experience by filling in a questionnaire.

According to Table 2, 72% of the participants (8 out of 11) scored over 70% (at least 5 out of 7) for the assessment. All the participants gave incredibly positive satisfaction ratings with only one participant giving a rating score of 4 out of 5. All participants commented on how "cool" the experience was and stated that they enjoyed learning differently.

Table 6: Assessment mark and overall rating

Participant	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11
Mark out of 7	4	3	5	5	7	6	6	6	4	5	5
Mark Percentage	57%	43%	71%	71%	100%	86%	86%	86%	57%	71%	71%
Rating out of 5	5	5	5	5	5	5	5	5	5	4	5
Rating Percentage	100%	100%	100%	100%	100%	100%	100%	100%	100%	80%	100%

9.2.4 Expectation Measure

According to Figure 9, the results of the expectation measure were between the "Promote It" quadrant and the "Don't touch it" quadrant. This reveals that although there is room for improvement, participants found the tasks relatively easy. Before performing the test tasks, participants were observably unsure about the difficulty of the tasks and mentioned that they were quite nervous about using the virtual device as they have never used anything similar before. However, after using the equipment and doing the tasks, their experience feedback was very positive.

Table 7: Expectation measure per task

Tasks	Average Expectation Rating	Average Experience Rating
Task 1	4,45	5,73
Task 2	3,64	5,18
Task 3	3,64	6
Task 4	4	5,63

Figure 14: Expectation measure results

9.2.5 Discussion of Results

As mentioned, learners in South Africa are still generally taught according to a paper-based method (PRESS OFFICE: Nashua, 2016). The implementation of virtual reality in learners' education is still in its infancy. Therefore, it came as no surprise that participants expected the virtual reality experience to be quite daunting. This was confirmed by the expectation measure results. However, the experience measure indicated that their actual experiences were positive in comparison to their expectations. These results also confirm that society has raised a digitally literate generation who are able to use technology when needed (OECD, 2016).

Although most participants did quite well in the assessment, the researchers perceived that since the participants were new to virtual reality, this attributed to the outliers in terms of longer times to complete the tasks, as shown in Figure 7. In future, participants would need to get more accustomed to using the virtual reality device beforehand, which should decrease the time it would take to complete each task. To illustrate: although participant 7's time in completing task 2 and task 4 was above the mean range, she did exceptionally well in the assessment.

Many of the participants had minor issues with task 2 and task 4 because they did not read the instructions correctly. This needs to be addressed by adding additional functionality to future versions of the prototype so that the instructions could be read out aloud to participants to improve the task success of each task.

Although there is a need for enhancements, the evaluation of the prototype revealed that there is great potential for the incorporation of virtual reality within the education system. This aligns with the statement by VIAR (n.d.) that virtual reality has the power to improve how learning concepts are taught to learners and allows them to experience and take charge of their education.

10. Contribution

This research provides proof that the incorporation of virtual reality within the education system could potentially eradicate the current issues experienced within teaching and learning. In providing virtual reality lessons as an additional method of teaching and learning. These types of technologies could be leveraged to bring about growth and promote individualism within child learning. The research also indicated that although learners might initially feel cautious, scared, or even overwhelmed by the idea of using new technologies in education, they are more than capable to use these technologies (in this case virtual reality).

11. Limitations and Future Work

The occurrence of the COVID-19 pandemic posed a big challenge to the evaluation of the prototype. The acquisition of test participants who were willing and had the consent of their parents or guardians was difficult. The researchers had to ensure that all the correct precautionary measures were put in place that would not only keep the participants safe but the researchers as well. Therefore, even though more participants would have been preferred, the evaluation results are still meaningful based on the "magic number 5" (Nielsen & Landauer, 1993; Lewis, 1994; Virzi, 1992) that indicates that about 80% of usability issues will be observed with the first five participants.

This article focused on one virtual reality lesson for learners between the ages of 10 and 13 in the Science discipline, teaching the process of Photosynthesis specifically. All these parameters could be expanded in future research. Additionally, virtual reality lessons could be extended to different subjects in school and do not have to be limited to the Natural Sciences.

Although the use of technology in education has increased in response to the challenges presented by the COVID-19 pandemic, future research should also investigate whether the South African education system has adequate resources to combat the ever-growing digital divide that exists within the education sector.

12. Conclusion

The purpose of this research study was to determine whether virtual reality could potentially have a positive effect on teaching and learning within South Africa – particularly in child education. The benefits that resulted from utilising virtual reality to portray specific educational content were very promising.

With all our lives completely changing due to the COVID-19 pandemic, the flaws of traditional education methods have been revealed, thus making room for new, improved, and innovative teaching and learning methods. Therefore, the researchers believe that to solve this failing teaching and learning system revealed by the pandemic, more time and resources need to be used in incorporating new technologies within education, with virtual reality being a very good candidate.

13. References

Adams, J. (2021, September 15). *Is 'traditional teaching' obsolete in the new era of blended learning?* Retrieved from DisplayNote: https://www.displaynote.com/blog/is-traditional-teaching-obsolete-in-the-new-era-of-blended-learning

Albert, W., & Dixon, E. (2003). Is this what you expected? The use of expectation measures in usability testing. *Proceedings of Usability Professionals Association 2003 Conference.* Scottsdale, AZ.

Amnesty International. (2020, February 11). *News: South Africa: Broken and unequal education perpetuating poverty and inequality*. Retrieved from Amnesty International: https://www.amnesty.org/en/latest/news/2020/02/south-africa-broken-and-unequal-education-perpetuating-poverty-and-inequality/

Asok, D., Abirami, A., Angeline, N., & Lavanya, R. (2016). Active Learning Environment for Achieving Higher-Order Thinking Skills in Engineering Education. *IEEE 4th International Conference on MOOCs, Innovation and Technology in Education*, 47-53.

Baukal, C. E., Ausburn, F. B., & Ausburn, L. J. (2013). Journal of Educational Technology. *A Proposed Multimedia Cone of Abstraction: Updating a Classic Instructional Design Theory*, 15-24.

Boyce, P. (2019, August 18). *Schools Are Outdated. It's Time For Reform*. Retrieved from FEE Stories: https://fee.org/articles/schools-are-outdated-its-time-for-reform/

Caroline. (2021, March 5). *LMS Knowledge Center: Online learning vs Traditional learning*. Retrieved from EasyLMS: https://www.easy-lms.com/knowledge-center/lms-knowledge-center/online-learning-vs-traditional-learning/item12530

Cicekci, M., & Sadik, F. (2019). Teachers' and Students' Opinions About Students' Attention Problems During the Lesson. *Journal of Education and Learning*, 15-30.

Dale, E. (1969). *Audiovisual methods in teaching.* New York: Dryden Press.

Davis, B. (2021, May 31). *What is tutorial method of teaching?* Retrieved from Mvorganizing: https://www.mvorganizing.org/what-is-tutorial-method-of-teaching/

Dimec, D. S., & Strgar, J. (2017). Scientific Conceptions of Photosynthesis among Primary School Pupils and Student Teachers of Biology. *C.E.P.S Journal*, 49-68.

eiffelcorp. (2018, July 5). *THE IMPACT OF TECHNOLOGY ON EDUCATION IN RURAL SA*. Retrieved April 18, 2020, from eiffelcorp - News Centre: https://www.eiffelcorp.co.za/the-impact-of-technology-on-education-in-rural-sa/

Eisenberg, A. (n.d.). *VR Environment: What Is It and How Does It Work?* Retrieved April 17, 2020, from AppReak: https://appreal-vr.com/blog/virtual-reality-environment-what-is-it-and-how-it-works/

Etikan, I. (2016). Comparison of Convenience Sampling and Purposive Sampling. *American Journal of Theoretical and Applied Statistics, 5*(1), 1.

Hassan, A. (2021, February 22). *Virtual Reality in Education: Achievements and Challenges*. Retrieved from EmergingEdTech: https://www.emergingedtech.com/2021/02/virtual-reality-in-education-achievements-challenges/

Katharina. (n.d.). *Passive vs Active Learning, What's Most Effective?* Retrieved from Mosalingua: https://www.mosalingua.com/en/passive-vs-active-learning/

Lewis, J. (1994). Sample Sizes for Usability Studies: Additional Considerations. *Human Factors, 36*(2), 368-378.

LSU Online. (2020, June 19). *Blog: How Virtual Reality is Chaging Education*. Retrieved from LSU Online: https://online.lsu.edu/newsroom/articles/how-virtual-reality-changing-education/

Mtantato, S. (2018, March 23). *Education: Basic education is failing the economy*. Retrieved from Mail&Guardian: https://mg.co.za/article/2018-11-23-00-basic-education-is-failing-the-economy/

Nielsen, J. (2012, January 15). *Thinking Aloud: The #1 Usability Tool*. Retrieved from Nielsen Norman Group: https://www.nngroup.com/articles/thinking-aloud-the-1-usability-tool/#:~:text=Definition%3A%20In%20a%20thinking%20aloud,move%20through%20the%20user%20interface.&text=Recruit%20representative%20users.,the%20users%20do%20the%20talking.

Nielsen, J., & Budiu, R. (2021, July 20). *Success Rate: The Simplest Usability Metric*. Retrieved from NNg: https://www.nngroup.com/articles/success-rate-the-simplest-usability-metric/

Nielsen, J., & Landauer, T. (1993). A mathematical model of the finding of usability problems. *Proceedings of ACM INTERCHI'93 Conference*, 206 -213.

Oculus. (n.d.). *Oculus Rift*. Retrieved from Oculus: https://www.oculus.com/rift/

OECD. (2016). *Trends Shaping Education.* Paris: OECD Publishing.

PRESS OFFICE: Nashua. (2016, May 19). *Paperless classrooms in South Africa – inevitable or doubtful?* Retrieved from How we made it in Africa: https://www.howwemadeitinafrica.com/paperless-classrooms-sa-inevitable-doubtful/54461/

Reily, M. (2016, April 26). *Is virtual reality the next step in education?* Retrieved from GoodEReader: https://goodereader.com/blog/digital-publishing/is-virtual-reality-the-next-step-in-education

Ross, M. (2015, January 4). *The flaws of today's education system*. Retrieved from TeenInk: http://www.teenink.com/opinion/school_college/article/753217/The-Flaws-of-Todays-Education-System/

Roussou, M. (2001). Immersive Interactive Virtual Reality and Informal Education. *Proceedings of i3 Spring Days 2000*.

The journey to 4IR: Equipping today's Chemical Engineering students with skills for tomorrow's workplace

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Abstract
The Fourth Industrial Revolution (4IR) is changing how we work. The next generation of workers needs to get ready for the new era by acquiring specific skill sets. Higher Education Institutions need to prepare students for a 4IR era to meet the needs of changing work environments. In a project launched at the University of KwaZulu-Natal in South Africa (SA), we focus on Chemical Engineering students and examine how the current curriculum prepares undergraduate students for the 4IR. The aim is to transform the undergraduate curriculum at one School of Engineering to adapt to changes in society, technology, and the African environment, specifically the South African context. The project is based on a mixed-method design, including analysis of curriculum documents, questionnaires and focus group interviews with stakeholders from Industry to rank relevant 4IR skills of Chemical Engineers in an African context. In this paper, initial results are presented, focusing on the 4IR skills needed by future generations of Chemical Engineers in SA, followed by a reflection on the dynamics in developing countries and which role the 4IR plays in such contexts. The project is pertinent because it will contribute to curriculum transformation by developing a blueprint which can then be used in other STEM disciplines in the future. Transforming the curriculum of Chemical Engineering in preparation for the 4IR is crucial if Higher Education Institutions want to continue to offer high-quality Education that is relevant locally and globally.
Keywords: Fourth Industrial Revolution, 4IR, Chemical Engineering, Curriculum Transformation, 4IR Skills

1. Introduction

A fundamental change in the social and financial conversions in societies is taking place. In response to this, the term Fourth Industrial Revolution (4IR) was coined. The 4IR is characterized by a combination of novel technologies that distort the relationships between the physical, digital, and biological domains of our world. Novel technologies have emerged and will continue to emerge that have the potential to revolutionarily change and reshape our lives by allowing us to constantly move between the digital domain and offline reality (Xu, David & Hi Kim, 2018). Such technologies do not only reshape our personal life but also affect how we work.

The 4IR has gained increasing attention. Its relevance is related to a drastic change in our personal and work lives due to novel technologies. However, critical voices caution against these developments. Some authors describe the 4IR as a double-edged sword for sustainable development (Diño & Ong, 2019). Others reflect on differences between countries in the movement towards the 4IR (Abdullah, Abdullah & Salleh, 2017). Especially in developing countries with limited technological resources, it might be challenging to move to the 4IR. A project was initiated in March 2021 at the University of KwaZulu-Natal in South Africa to adapt the curriculum in Chemical Engineering to meet the needs of graduates in their future 4IR workplace. In this paper, the design of the project and first results on 4IR skills are presented, followed by a critical reflection on the 4IR in developing countries.

2. The Impact of the 4IR on Workplaces

A shift is already happening towards different sets of skills of workers. In a comparison of the skills workers needed in 2015 and 2020, the World Economic Forum (WEF; Gray, 2016) highlights that skills such as complex problem solving or people management were expected to still rank high in 2020 while

other skills have moved up in relevance. In 2020, creativity made it to the third highest rank on the list. The ability to think critically moved from rank four in 2015 to two in 2020. Other skills have emerged on the 2020 list, which have not been among the most important skills in 2015. The highest skill growth rates were reported for cognitive abilities (e.g., cognitive flexibility, creativity), systems skills (judgement and decision-making), and complex problem solving (World Economic Forum, 2016). Substantial shifts in the skills relevant in the workforce were predicted to happen in a short period of time. Skills considered highly relevant for a long time have lost some relevance (e.g., negotiation skills) or have been removed from the top 10 (e.g., quality control). An even more substantial shift is expected to take place over the next decades.

While some skills may be relevant to workers across industries, we might also find somewhat different skill sets for workers dependent on the Industry (World Economic Forum, 2016). The 2016 report by the World Economic Forum has already shown that the financial, infrastructural and mobility sectors report the highest skill instability rates. The 4IR is going to influence the workplace by causing changes in the way we work and operate. Most of our work has moved online. We do not only communicate online but also bank and work online. This development has been catalysed by the COVID-19 pandemic, which required many to work, learn, communicate and shop remotely. New business models were created, and new socio-economic developments are emerging (Oosthuizen, 2017). Novel technologies affect businesses, and new skill sets are required, including emotional intelligence or entrepreneurial intelligence (Oosthuizen, 2017). These new skills become increasingly relevant so that employees operate efficiently and effectively. Apart from these two examples, a diverse skill set will be required of employees in order to work in the 4IR world, for example, skills such as complex problem solving, critical thinking, and creativity are some skills that are now more often mentioned as relevant in the workplace (WEF; Gray, 2016). Apart from these, diverse technical skills are required in other aspects of work, including technological designing and programming skills (Armstrong, Parmelee, Santifort, Burley & Van Fleet, 2018). More and more 4IR skills such as people management, coordinating with others, decision-making and being accountable for those decisions are becoming relevant (WEF; Gray, 2016).

These developments are often met with great excitement and enthusiasm. There are, however, some critical voices. Garibaldo (2016), for example, argues that these technological changes and transformations do have consequences, and one of them is that they may cause increased levels of unemployment. The 4IR is accompanied by novel technologies such as robotic systems, big data analytics, cloud computing, augmented reality, Internet of Things, 3D printing or simulation prototypes (Kamble, Gunasekaran & Gawankar, 2018). Some occupations may change dramatically or become obsolete with the advancement of such technologies. In Japan, robots already administer medication to patients and assist with moving patients from one bed to the next. For the youth to stay relevant and competitive, they need to be fully equipped and prepared for this new era (Butler-Adam, 2018). Higher Education Institutions have a mandate to equip their graduates with the skills necessary to meet current and future requirements in a 4IR work environment.

This environment is going to evolve and take on different shapes with the advancement of technology. Thus, skills also have to meet such adaptation requirements. Previously relevant skill sets need to be rethought, and graduates must be prepared for such a dynamic work environment. Higher Education curricula, thus, need to be transformed to equip the next generation of intellectuals for the 4IR (Gleason, 2018). As much as Higher Education Institutions had to take first steps to adapt to this change in recent times, a comprehensive long-term plan needs to be in place to allow for the preparation of graduates for a changing work environment and developing relevant 4IR skills, which vary somewhat depending on the regional, educational or industrial context.

3. The Impact of the 4IR on Engineering

Globally, sectors such as office and administration or manufacturing and production have been predicted to see a decline in their workforce (World Economic Forum, 2016). One of the disciplines that is already affected and will be affected by the 4IR substantially is Engineering (Kenett, Swarz & Zonnenshain, 2019). In Engineering, substantial drivers for change are robotics, climate change and natural resources, the Internet of Things or advanced manufacturing (World Economic Forum, 2016). Engineering is going to keep changing substantially with the development and advancement of such drivers. With modern communication systems encompassing the internet, robotics and artificial intelligence, future Engineers need to be equipped with the relevant skills (Ilori & Ajagunna, 2020). Therefore, curricula have to be reorganised in order to incorporate these aspects. Internationally, some initiatives move in this direction. Kocdar, Bozkurt and Goru Dogan (2021) indicate that the Engineering curriculum in the United States of America, Spain, and Germany has been adapted for Engineering students, more so in distant learning. Their curriculum has been restructured in order to include three major strands, namely; (I) technology-enhanced distance Engineering Education, (II) e-learning and m-learning, and (III) virtual and remote labs. Curricula must be economically, culturally, disciplinarily and learning responsive in the 4IR and Engineering (Formunyam, 2020).

Consequently, curricula need to be constantly updated to accommodate societal changes (Ilori & Ajagunna, 2020). Formunyam (2020) argues that we need to start deterritorialising (move away from established paths) to be able to reterritorialise the curriculum (restructure, rebuild new pathways) in order to equip graduates with the necessary skills to adapt to changes in technology. The Engineering curriculum also needs to be adapted to become more student-centred, incorporating e-learning, novel pedagogical methods and refocused Engineering skillsets to embrace such changes (Bühler, Nübel & Jelinek, 2021).

4. The Current Project

A project was initiated in March 2021 at the University of KwaZulu-Natal in South Africa, funded by the JW Nelson Foundation. The main objectives of this project are to identify relevant 4IR skills for Chemical Engineers in South Africa and develop a plan on how to implement these into the curriculum in Chemical Engineering, which will then function as a blueprint for the curriculum adaptation in other Engineering and STEM disciplines.

The project team consists of researchers from different disciplines and with complementary expertise (Engineering, Education, Work and Organisational Psychology), which allows for a transdisciplinary approach. The project is based on a mixed-method design. In order to identify relevant 4IR skills of Chemical Engineers, a series of steps are taken. First, a comprehensive literature review identifies the 4IR skills discussed in the literature and different contexts. As part of this analysis, a search for publications was conducted on Web of Science with the keywords 4IR, Fourth Industrial Revolution, 4th Industrial Revolution and Industry 4.0, all of which were combined with the Boolean phrase OR to include all relevant publications. The keyword 'skills' was entered into the search using the Boolean phrase AND to identify relevant publications, which also focused on skills. The search was limited to include only the following publications: articles, proceeding papers, book chapters, early access papers published between January 2000 until July 2021. Results were then analysed descriptively (counts, frequencies) in Web of Science. Results were downloaded as .ris files and entered into a bibliographical programme (Endnote X7.8; The Endnote Team, 2013). Files were then introduced in VOS viewer (www.vosviewer.com; Van Eck & Waltman, 2010, 2014). This programme allows for an analysis of bibliographical information to identify networks of keywords or authors.

Based on this, stakeholders from Industry, Higher Education and other institutions are invited to rate relevant skills according to relevance in a questionnaire. Results will then be discussed in a stakeholder workshop (focus group discussion) to finalise which skills are relevant for Chemical Engineers to meet

the needs of the Industry in the 4IR. This will then inform the adaptation of the curriculum at the respective Higher Education Institution and can also inform initiatives at other institutions in South Africa or on the African continent. Moreover, in order to adjust the curriculum, an analysis is conducted to identify a) which overall skills are addressed in the teaching of undergraduate Chemical Engineering students at this particular Higher Education Institution, b) which skills have become relevant with the move the remote teaching in response to the COVID-19 pandemic and c) to analyse and provide suggestions which skills to foster and which new skill sets need to be focused on in the teaching of the future generation of Chemical Engineers to meet the need of the changing Industry in South Africa. This analysis is initially based on a content analysis of existing module information and blank assessments. In this paper, the focus is on the introduction of the project, the presentation of initial results on relevant 4IR skills and a critical discussion of the role of 4IR in a developing country context.

5. Results and Discussion

First, a synthesis of the literature on skills and 4IR is provided. Based on the literature search on Web of Science, an analysis was conducted on relevant 4IR publications worldwide. It becomes clear that 4IR (and related terms) has indeed become a buzzword. Overall, 4.071 relevant publications were identified between January 2000 and July 2021. The vast majority were published since 2015 (n=3.951, 97%), with exponential growth since 2015, which slowed down in 2020. Results for 2021 results are still inconclusive, but the publication numbers in the first seven months of 2021 indicate that levels may not reach the same level as in 2019 (see figure 1).

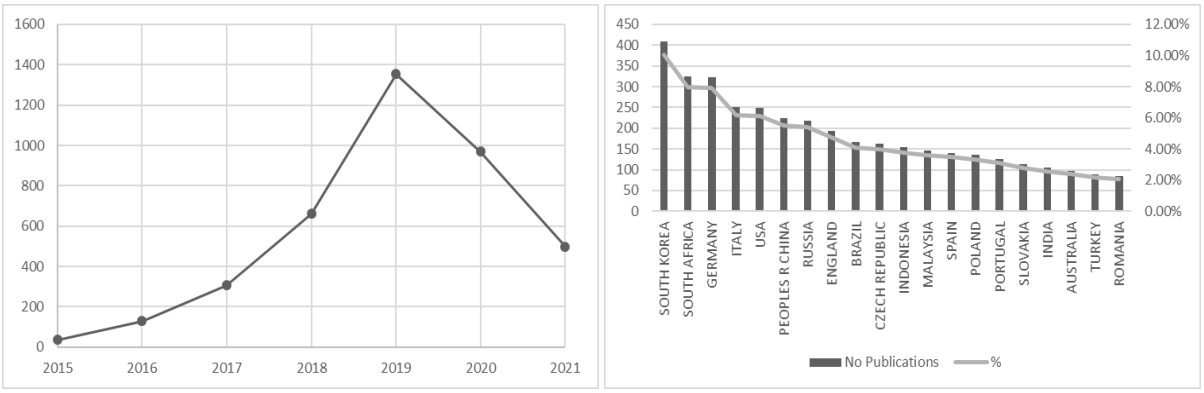


Figure 1: Number of resulting publications retrieved from Web of Science (search terms 4IR OR Fourth Industrial Revolution OR 4th Industrial Revolution Industry 4.0 AND skills) per year (left, all publications) and number and percentage of publications per country (right, top 20 countries publishing in this field).

Unsurprisingly, many of the countries focusing on skills in the 4IR arena are developed countries. It was, however, surprising to note that 4IR skills seem to receive intense attention in a developing country: The second-highest number of publications came from South Africa (76 more publications than the US; see figure 1).

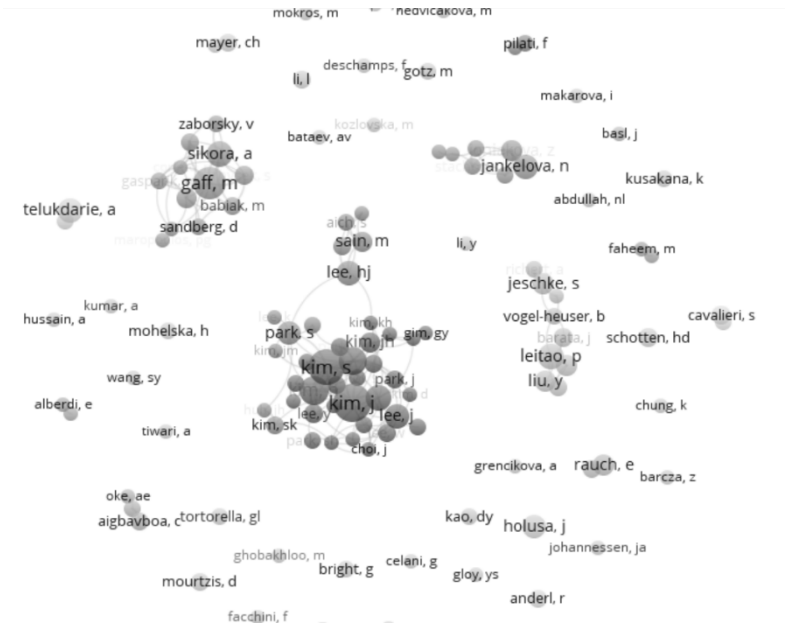
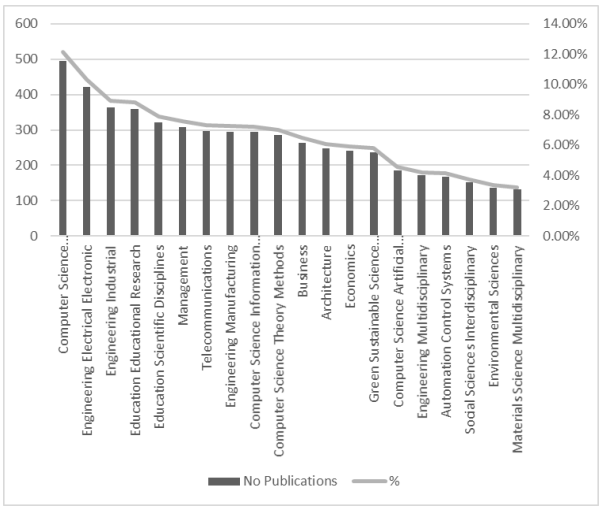


Figure 2: Results of network analysis of co-authorship in all publications conducted in VOS viewer (Van Eck & Waltman, 2010, 2014; N=4.071).

A network analysis of the results shows that clusters of authors exist (see figure 2) with very little interlinkage. Of these, a large number was published in Engineering (n=1.237, 30% of publications), and Educational research ranks fourth (n=647, 16%). Analysing the categories research was published in, it becomes clear that the 4IR skills play a major role in many areas of Engineering (see figure 3). The majority of publications focused on Electrical, Industrial, Manufacturing Engineering and Multidisciplinary Engineering.



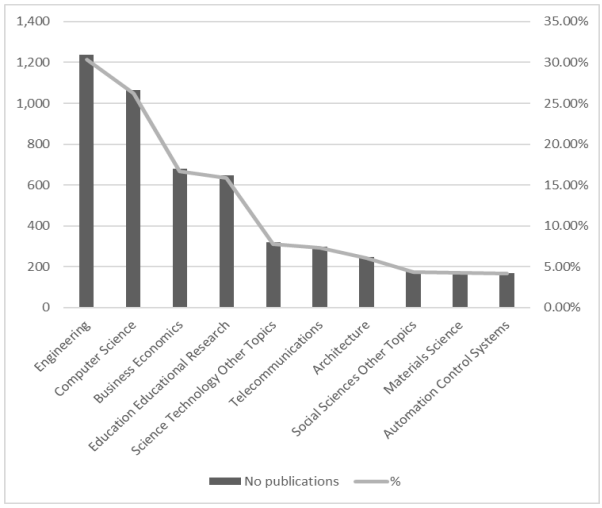


Figure 3. Results of Web of Science Search (as of 10 August 2021) on number and percentage of publications according to research categories (left, top 20) and according to research areas (right, top 10).

A second network analysis of the results according to co-occurrences of central terms has resulted in interesting patterns. Overall, a high interlinkage of all terms could be identified. Examining patterns reveals that Industry 4.0 seems to be a buzzword that interlinks with many other research topics. However, research focusing on the Fourth Industrial Revolution seems to be more linked to Educational topics. It includes links to skills relevant to the 4IR (such as 21st-century skills).

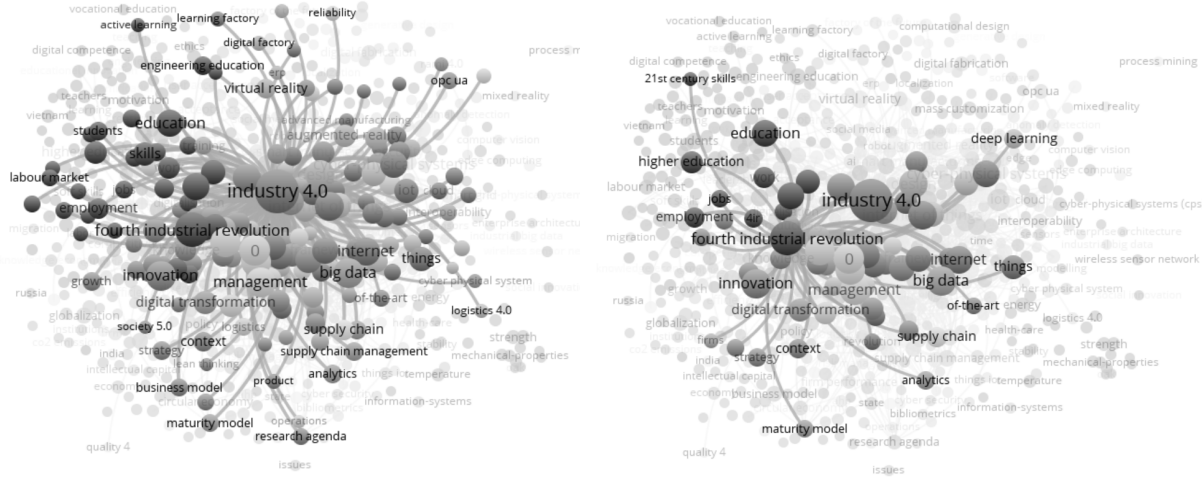


Figure 4: Network analysis using VOS viewer (Van Eck & Waltman, 2010, 2014) with focus on Industry 4.0 (left) and Fourth Industrial Revolution (right) (N=4.071).

Next, relevant 4IR skills are summarized. Various lists of skills have been published in different domains (e.g., Education, Engineering, Industry). A summary of different skill categorizations is provided in table 1. Whereas Industry focuses more on future work skills, 21st-century skills are predominantly discussed in Education but have also received attention in the Business sector. Thus, the different conceptualizations of 4IR skills in these two sectors are captured in separate rows in table 1.

Table 1: Summary of different skill categorisations, specific focus on skills of Engineers.

Future Work Skills 2020	**Future of Work Skills**	**21st Century Skills (Education)**	**21st Century skills (Business/Finance)**	**Engineering skills**
Sensemaking	Analytical thinking	Critical thinking	Creativity and innovation (ways of thinking)	Understand and apply Engineering principles
Novel & adaptive thinking	Holistic thinking	Creativity (learning skills)	Critical-thinking (ways of thinking)	Reasoning, analytical and problem-solving skills
Social intelligence	Active learning	Collaboration (learning skills)	Problem-solving (ways of thinking)	Synthesise information and draw conclusions
Computational thinking	Ideation	Communication (learning skills)	Decision-making (ways of thinking)	Critical thinking
Transdisciplinarity	Tech design and programming	Information literacy (literacy skills)	Learning to learn (ways of thinking)	IT skills
New media literacy	Reasoning	Media literacy (literacy skills)	Metacognition (ways of thinking)	Process modelling and simulation

Cognitive load management	Systems analysis and evaluation	Technology/ICT literacy (literacy skills)	Communication, collaboration, tools for working, information literacy and ICT literacy (ways of working)	Safety awareness and environmental impact awareness
Design-mind set	Judgment and decision making	Flexibility/Adaptability	Collaboration (ways of working)	Resource management
Cross-cultural competency Virtual collaboration	Leadership and social influence Diversity and cultural intelligence	Leadership/responsibility Initiative/self-direction	Tools for working (ways of working) Information Literacy (ways of working)	Specialised software use Obeying regulatory requirements
Digitalisation	Negotiation and coordinating with others Interpersonal communication skills, emotional intelligence and self-confidence Productivity and accountability	Productivity/ accountability Social and cross-cultural skills	ICT Literacy (ways of working) Citizenship, life and career skills, personal and social responsibility (living in the world)	Commercial and business awareness
(Davies, Fidler & Gorbis, 2011)	(Armstrong *et al.* 2018; Batelle for Kids, 2019; Menon & Castrillón, 2019; Gleason, 2018; Kamaruzaman *et al.*, 2019; Kamp, 2019; Marr, 2019; Wessels, 2020; UNESCO & ICEE, 2021)	(Stauffer, 2020)	(Binkley *et al.*, 2012)	AGCAS & Graduate Prospects Ltd, 2021; Illinois Career Information System, 2021; AGCAS & Graduate Prospects Ltd, 2021; Cheptoo, 2014; International Engineering Alliance, 2013; TARGETjobs, 2021)

Many of the identified skills are listed across table 1 and are discussed in different areas of research. For example, creativity is represented in the Business, Financial, Educational and Chemical Engineering sectors. Other skills such as analytical thinking or critical thinking, decision-making are also represented in the different research areas. Therefore, it can be concluded that these lists have a common understanding of skills needed in the future so that employees meet the demands of the 4IR. However, a closer look reveals that these skill sets differ in how they are subdivided. For example, the Applied Education Systems by Stauffer (2020) breaks down skills into learning skills, literacy skills and life skills. In contrast, the 21st-century skills represented by Binkley *et al*. (2012) are divided into the following sections: ways of thinking, ways of working and living in the world. An even more detailed look at these skill categorisations reveals that skills differ in how they are defined and understood in these different domains. Creativity in the Business sector or Chemical Engineering suggests that people are required to come up with something new and innovative. However, in Education, it refers to using resources or material we already have and transforming these into something novel and creative. Thus, such skills summaries need to be considered carefully in how skills will play out in different domains. When including them in teaching and learning, discipline-specific strategies need to be developed.

The skill range expected of Chemical Engineers is quite broad (see table 1). It includes skills such as understanding and applying Engineering principles and mathematics, using scientific methods to solve Engineering problems or analytical and problem-solving skills, which seem to be obvious choices. However, Chemical Engineers in the future need a broader set of skills that also include critical thinking, decision making, or project management skills that will allow them to adapt to new conditions and move into managerial positions. Moreover, skills such as environmental impact awareness, commercial and business awareness, change management skills or adaptability and flexibility, creativity, and innovation will be required to complement the more traditional skills. These are required in an environment that is constantly changing. The focus will more and more be on environmental problems that require creativity to 'think outside the box' and find novel solutions to problems.

Of course, such lists also depend on the context, and it is necessary to focus on which skills will be required in which geographical or social context. The project is going to build on this information and identify and rank skills relevant to Chemical Engineers in a Southern African context. These skills are then to be developed and fostered in teaching future (Chemical) Engineers, enabling them to adapt, be creative, innovative, and flexible. These skills go hand in hand and will ensure success in our ever-changing world and contribute positively to society.

6. Reflection on 4IR in Developing Countries

The analysis presented in figure 1 points towards the interesting observation that 4IR skills are not only a focus area in developing countries, but is particularly receiving attention in South Africa. South Africa faces tremendous challenges which seem debilitating to a 4IR environment (e.g., power cuts, lack of financial resources, educational disparities). One could argue that under such conditions, South Africa has not fully arrived in the 4IR yet. Elsewhere, the onset of the 3rd Industrial Revolution (3IR) occurred in the 1960s with the advancement in electronics and Information Technology (IT), and forty years later, the 4IR began with the advancement in computer-generated designs, 3D printing and genetic Engineering (Schwab, 2016). The entire African continent faces diverse challenges when dealing with modernisation and sustainable development, making it difficult to embrace change and move towards the 4IR. Uleanya and Ke (2019) reiterate that the African continent is not sufficiently prepared for this Industrial Revolution. Naudé (2017) states that the implications of the African continent not being ready for the changes could leave the continent behind as the world changes. Thus, it is not clear if South Africa has indeed made a move towards the 4IR yet. However, publications on the 4IR are thriving, which can be interpreted as a sign of readiness to move in this direction.

The African continent is said to have the potential for a technological clasp by 2050. It thus may have the ability to embrace the 4IR by 2050, focusing on innovation and development. This development can foster entrepreneurship which can be a major driver of economic growth. Moreover, participation in society can be strengthened for the youth in South Africa. They stay connected via digital platforms and have access to information and resources, which will foster creativity, innovation, and entrepreneurship. Apart from such positive developments and opportunities for youth, there are also some concerns related to automation. With increasing automation and other technological changes and transformations, unemployment levels may rise (Garibaldo, 2016). In an economy that is already characterised by high levels of unemployment, this may prove a major challenge in the next decades. The question will be how to adapt to such technological changes in a context-specific and equitable way that addresses the specific situation in South Africa.

Higher Education Institutions, thus, have to prepare graduates for such future challenges. Currently, the concern is that graduates are not adequately qualified for this future, resulting in a gap when moving into work (Benešová & Tupa, 2017).

This project is highly relevant in contributing to adequately equipping graduates in (Chemical) Engineering with skills to prepare them for work and foster future economic growth. Engineering graduates are employed in a diverse industry that is constantly going through fluctuations. The need for adaptation of curricula at Higher Education Institutions remains a challenge so that future Engineers adapt to the changes that Industry and the world will face, are enabled to actively address challenges in the workspace and society, and proactively shape their future.

7. Acknowledgements

This project entitled "Transforming the curriculum and its delivery in preparation for 4IR: Equipping today's students with knowledge and skills for tomorrow's workplace" is funded by the JW Nelson Endowment Fund Trust. This work is based on research supported in part by the National Research Foundation of South Africa (grant number: 115465). We are indebted to Profs. Bright, Tapamo and Lokhat (School of Engineering) for institutional support.

8. References

Abdullah, D. B., Abdullah, M. Y., & Salleh, M. A. M. (2017). A review on the concept of Fourth Industrial Revolution and the government's initiatives to promote it among youths in Malaysia. *e-Bangi*, *14*(7).

AGCAS & Graduate Prospects Ltd. (2021, March). *Job profile Chemical Engineer*. Retrieved from Prospects: https://www.prospects.ac.uk/job-profiles/chemical-engineer (Accessed 19 July 2021).

Armstrong, K., Parmelee, L., Santifort, S., Burley, J., & Van Fleet, J. W. (2018). *Preparing Tomorrow's Workforce for the Fourth Industrial Revolution for Business: A Framework for Action.* Deloitte & The Global Business Coalition for Education.

Benešová, A., & Tupa, J. (2017). Requirements for education and qualification of people in Industry 4.0. *Procedia Manufacturing*, *11*, 2195-2202.

Battelle for Kids. (2019). *Framework for 21st Century Learning.* Hilliard: Battelle for Kids. Retrieved from https://www.battelleforkids.org/networks/p21/frameworks-resources (Accessed 15 August 2021).

Binkley, M., Erstad, O., Herman, J., Raizen, S., Ripley, M., Miller-Ricci, M., & Rumble, M. (2012). Defining twenty-first century skills. In *Assessment and teaching of 21st century skills* (pp. 17-66). Dordrecht: Springer.

Bühler, M. M., Nübel, K., & Jelinek, T. (2021). Educating Tomorrow's Workforce for the Fourth Industrial Revolution–The Necessary Breakthrough in Mindset and Culture of the Engineering Profession.

Butler-Adam, J. (2018). The fourth industrial revolution and education. *South African Journal of Science*, *114*(5-6), 1-1.

Cheptoo, A. (2014, August 14). *Top 10 Must-Have Skills for Chemical Engineers*. Retrieved from CareerAddict: https://www.careeraddict.com/top-10-must-have-skills-for-chemical-engineers (Accessed 19 July 2021).

Davies, A., Fidler, D., & Gorbis, M. (2011). *Future Work Skills 2020*. Institute for the Future for University of Phoenix Research Institute. Palo Alto, CA. Retrieved from: https://www.iftf.org/uploads/media/SR-1382A_UPRI_future_work_skills_sm.pdf (Last accessed 15 August 2021).

Diño, M. J. S., & Ong, I. L. (2019). Research, technology, education & scholarship in the fourth industrial revolution [4IR]: Influences in nursing and the health sciences. *The Journal of Medical Investigation*, *66*(1.2), 3-7.

Fomunyam, K. G. (2020). Deterritorialising to Reterritorialising the Curriculum Discourse in African Higher Education in the Era of the Fourth Industrial Revolution. *International Journal of Higher Education*, *9*(4), 27-34.

Garibaldo, F. (2016). Industry 4.0. *Position Paper*.

Gleason, N. W. (2018). *Higher education in the era of the fourth industrial revolution* (p. 229). Springer Nature.

Gray, A. (2016). *The 10 skills you need to thrive in the Fourth Industrial Revolution*. Retrieved from https://www.weforum.org/agenda/2016/01/the-10-skills-you-need-to-thrive-in-the-fourth-industrial-revolution/ (Accessed 04 August 2021).

Illinois Career Information System. (n.d.). *CHEMICAL ENGINEERS*. Retrieved from Illinois workNet center: https://apps.illinoisworknet.com/cis/clusters/OccupationDetails/100034?parentId=111500&sectio=skills&sectionTitle=Skills%20and%20Abilities (Accessed 19 July 2021).

Ilori, M. O., & Ajagunna, I. (2020). Re-imagining the future of education in the era of the fourth industrial revolution. *Worldwide Hospitality and Tourism Themes*.

International Engineering Alliance. (2013). *Graduate Attributes and Professional Competencies.* International Engineering Alliance.

Kamaruzaman, F. M., Hamid, R., Mutalib, A. A., & Rasul, M. S. (2019). Conceptual framework for the development of 4IR skills for engineering graduates. *Global Journal of Engineering Education, XXI*, 54-61.

Kamble, S. S., Gunasekaran, A., & Gawankar, S. A. (2018). Sustainable Industry 4.0 framework: A systematic literature review identifying the current trends and future perspectives. *Process Safety and Environmental Protection*, *117*, 408-425.

Kamp, A. (2019). Science & Technology Education for 21st Century Europe*. Discussion Paper.* CESAER.

Kenett, R. S., Swarz, R. S., & Zonnenshain, A. (Eds.). (2019). *Systems engineering in the fourth industrial revolution: Big data, novel technologies, and modern systems engineering*. John Wiley & Sons.

Kocdar, S., Bozkurt, A., & Goru Dogan, T. (2021). Engineering through distance education in the time of the fourth industrial revolution: Reflections from three decades of peer reviewed studies. *Computer Applications in Engineering Education*, *29*(4), 931-949.

Marr, B. (2019, April 29). *The 10 Vital Skills You Will Need For The Future Of Work*. Retrieved from Forbes: https://www.forbes.com/sites/bernardmarr/2019/04/29/the-10-vital-skills-you-will-need-for-the-future-of-work/?sh=4168d0c33f5b (Accessed 30 June 2021).

Menon, K., & Castrillón, G. (2019). Reimagining curricula for the Fourth Industrial Revolution. *The Independent Journal of Teaching and Learning*, 6-19.

Naudé, W. (2017). Entrepreneurship, education and the fourth industrial revolution in Africa.

Oosthuizen, J. (2017, September). The determinants of fourth industrial revolution leadership dexterity: A proposed framework for 4ir-intelligence and subsequent 4ir leadership development. In *4th International Conference on Responsible Leadership,* 30*(3)*, 243-259.

Schwab, K. (2016). The Fourth Industrial Revolution. What it Means and How to Respond Foreign Affairs. Retrieved from: https://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond (Accessed 15 August 2021).

Stauffer, B. (2020, March 19). *What Are 21st Century Skills?* Retrieved from Applied educational systems: https://www.aeseducation.com/blog/what-are-21st-century-skills (Accessed 03 May 2021).

TARGETjobs. (2021). *CHEMICAL (PROCESS) ENGINEER: JOB DESCRIPTION*. Retrieved from TARGETjobs: https://targetjobs.co.uk/careers-advice/job-descriptions/278829-chemical-process-engineer-job-description (Accessed 19 July 2021).

The Endnote Team (2013). *Endnote*. In Clarivate Anaytics.

Uleanya, C., & Ke, Y. (2019). Review of preparedness of rural African communities nexus formal education in the fourth industrial revolution. *South African review of sociology*, *50*(3-4), 91-103.

UNESCO and ICEE. (2021). *Engineering for Sustainable Development.* Paris: UNESCO.

Van Eck, N.J., & Waltman, L. (2010). Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics*, *84*(2), 523-538.

Van Eck, N.J., & Waltman, L. (2014). Visualising bibliometric networks. In Y. Ding, R. Rousseau, & D. Wolfram (Eds.), *Measuring scholarly impact: Methods and practice* (pp. 285-320). Springer.

Wessels, L. (2020). How South African universities can contribute to preparing the future workforce for the Fourth Industrial Revolution. Master Thesis Educational Psychology. Stellenbosch University. Retrieved from https://scholar.sun.ac.za/handle/10019.1/108143 (Accessed 15 May 2021).

Xu, M., David, J. M., & Kim, S. H. (2018). The fourth industrial revolution: Opportunities and challenges. *International journal of financial research*, *9*(2), 90-95.

World Economic Forum. (2016). The future of jobs: Employment, skills and workforce strategy for the fourth industrial revolution. *Global Challenge Insight Report*. http://www3.weforum.org/docs/WEF_Future_of_Jobs.pdf (Accessed 04 Aug 2021).

A Project-Based Approach to Building Organisational and Staff Capability at the University of South Pacific (USP) Emalus Campus, Vanuatu which is Strategic, Scaffolded and Sustainable

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Abstract
The design and provision of institute-wide professional development for staff working in higher education settings in developing and under-resourced countries, is both rewarding and challenging. It is particularly complex when English is not the first language of the participants and when previous exposure to staff development and team-based activities has been minimal. Face-to-face workshops designed to engage staff in workplace conversations and to identify staff and campus development needs were conducted at the Emalus Campus, Vanuatu in 2017 and 2018. These interactive sessions led to the development of 15 team-based projects. Fifty-four academic, professional, and administrative staff, including the campus director and senior campus managers attended these voluntary sessions and participated in the team building activities and project designs. Several original, tangible learning tools and artefacts were used in the workshops. They provided a bridge from theory to practice and gave the team members the confidence and know how to design and document their project plans and strategies. This report describes the professional development activities undertaken to arrive at the projects and final action plans for implementation during the period 2019. Formal evaluation of the project outcomes was impeded by the outbreak of the COVID-19 pandemic in 2020 which banned travel to Vanuatu to gather direct feedback from the participants. However, a report on the initial phases of the professional development program is worthy of dissemination and makes a significant contribution to discussion on the value of providing project-based staff profession development, especially in developing countries.
Keywords: project-based, staff professional development, strategic, scaffolded, sustained

1. Introduction

This case study grew out of collaborative discussions in 2017 with the leadership team at the Emalus campus of the University of South Pacific (USP) in Vanuatu. The purpose of the approach was to test the appetite for staff professional development programs at the campus. Just under twenty-five percent of staff responded to an initial survey that revealed that most respondents had not received any professional development, other than induction, in the previous two years. The survey results identified an interest in professional development, particularly in leadership development, student engagement, customer service, and innovative assessment design. The survey also revealed a staff preference for short one-day seminars or group workshops, in contrast to more formal study. As a result of this feedback, an initial staff professional development session was planned for both administrative and academic staff to flesh out the topics and decide on a format for a potential program. The positive response to this session led to a series of workshops delivered over the following two years, culminating in the group projects outlined in this case study.

2. Purpose

The intention of the professional development program implemented at Emalus Campus, Vanuatu was to build the capability of the university campus, as well as the capability of individual staff members. The various workshops on quality assurance and teamwork were designed to give staff the tools and confidence to tackle the 15, self-nominated projects. In addition, an aspirational goal was

that along the way, participation in these development activities would encourage a culture of life-long learning. The design and provision of institute-wide professional development for staff working in higher education settings in developing and under-resourced countries, is both rewarding and challenging.

3. Context

The University of the South Pacific (USP) is a public university in the Pacific / Oceania region. It is jointly owned by the governments of 14 participating island nations. In Vanuatu the Emalus Campus is in Port Vila. Emalus also operates four centres on outlying islands. During the period 2017 – 2019 student enrolments hovered between 900 - 1100. The campus offers courses in Law, Pacific Languages, Economics and recently Education. It also has a highly regarded Pacific Islands Legal Information Institute and a Francophone program. In most cases, English is not the first language of staff who are generally shy, and many of the administrative staff lack experience in public speaking and writing proficiently in English.

4. Trends in Higher Education Staff Professional Development

In recent years, there is evidence of increased commitment to staff professional development activity across the Higher Education sector and its link to staff retention, job satisfaction and perceived advancement (Fusch). However, the nature and quality of these programs vary from country to country and within countries. Some programs focus on individual staff induction and self-paced professional learning modules (NSW University). In institutes that have greater access to resources, the professional development programs focus on quality improvement, quality assurance and optimal technology delivery models to achieve academic excellence (Jacob et al).

Whilst individual staff professional development is valuable to an organisation, the provision of systematic staff development that embeds a culture of life-long learning as part of ongoing organisational and staff capability building, is an area that is often neglected or side-lined in a busy workplace. In this case study the aim was to build both organisational and staff capability using a project-based, interactive, problem-solving model driven by small staff teams.

5. Underpinning Theories and Research

The methodology applied in the Vanuatu Program can be traced back to a series of management, organisational behaviour, total quality management and action research theories that emerged during the twentieth century and have been expanded upon in the twenty-first century. The management theories that informed the methodology, were those that value staff participation and contribution in shaping their jobs and those that recognised the importance of collaborative workplaces. It is important to acknowledge that this approach originated from early research by Taylor (1911) who wrote *Principles of Scientific Management*. Taylor brought a quantitative, analytical approach to production-line workplaces. He recognised the contribution to efficiency and productivity of enabling employees to determine how the work was done. He also promoted collaboration between managers and workers, rather than perpetuating an adversarial relationship of boss and employees. Even though the concepts of management-worker collaboration and employees taking responsibility for making improvements to work outcomes, have been around for several years, they are often overlooked in contemporary workplaces. Collaboration and taking responsibility for making improvements were key underpinnings of the methodology and design of the staff professional development projects central to this case study.

While Taylor viewed the workplace through a scientific lens, Mayo's (1946) workplace research, particularly in the Hawthorne experiments, added a social relationships dimension to the nature and efficiency of workplaces. Like Taylor, Mayo found that employees were motivated by the perception that they were valued by their employers, had some ownership in the way they did their job. Mayo

hypothesised that employees found job satisfaction though social interaction and a sense of belonging to a group, more than through environmental or monetary incentives. Once again, even though the importance of social interaction has been around or some time, it was recognition of the value of social presence and trusted relationships in producing positive workplace outcomes that became a major design feature in the methodology adopted in the Vanuatu program.

Another management theory which is reflected in the approach to professional development used in this case study, is 'self-determination' theory. This theory was made popular in the mid-1980s by Deci and Ryan (1985). Their research into what motivates workers to perform well, found that an employee's level of engagement is strongly associated with their ability to control their personal behaviours and goals. In the professional development workshop activities conducted in the Vanuatu project, staff were encouraged to actively engage with colleagues and to discuss ways they and their team unit, could take greater control and ownership of their work area.

Acknowledgement of McGregor's (1985) Theory X and Theory Y management profiles, outlined in his book *The Human Side of Enterprise* was also taken into consideration in the design of this project. Theory X which refers to an authoritarian management style where managers determine how the job will be executed and micro-manage the process, was rejected in preference to a Theory Y, or participative approach. In the participative approach managers encourage their employees to take responsibility for their work. The Vanuatu program was designed to actively engage staff and give the group ownership of identifying a problem or blockage to their work-flow and taking responsibility for initiating improvements to their workplace and roles.

Whilst quality has become an accepted measure in contemporary organisations, including institutes of higher education, the origins of quality in the workplace can be traced back to the mid-nineteen hundreds. Deming (1956) applied the concept of quality to the management of companies and promoted a quality culture throughout the organisation.

Juran (1995). mainly worked with Japanese companies and took a holistic approach to quality, He tracked the quality of the entire production-cycle, not just the quality of the end-product or outcome. Two features of his approach, relevant to this study, were his ongoing quest for quality improvement and the value he placed on staff training and professional development.

The foundational work on quality management was taken even further in the late twentieth-century with the popularisation of Total Quality Management (TQM). The introduction of TQM in higher education is viewed as having mixed success (Koch & Fisher, 1998). However, its influence can be seen in quality assurance programs that focus on continual improvement, student and staff satisfaction, empowerment of employees, improvement in education delivery and work processes, excellent customer service, team-work, problem solving and measurement against standards and benchmarks (Cruickshank 2003). The introduction of variations on quality assurance cycles also emerged from this approach. Deming developed a quality cycle of Plan-Do-Check-Act (Moen & Norman (2009).

In the staff professional development workshop delivered in this case study, Bennett's (2008 and 2010) Engaging Leadership Framework (ELF) was used to guide staff through the improvement process. The ELF consists of a four-stage quality cycle of 'Evaluate' (start with an analysis of the data). 'Improve' (identify what needs to improve). 'Plan' (design the improvement activities, and 'Act' (implement the activities). This cycle was overlaid with a trilogy of excellence – excellence in scholarship, excellence in engagement and excellence in management.

The philosophy of Action Research (McNiff 2013 and Kember & Gow 1992) was another key influence in the development of the professional development programs designed for Vanuatu. Action Research

is a powerful tool. It incorporates authentic problem-solving and transformation by empowering the key players with the responsibility for identifying the underlying issues and obstacles and through collaboration, reflection, and negotiation, implementing the improvements.

Whilst the projects undertaken by the staff in Vanuatu varied in complexity, some proving quite easy to solve, often involving little more than a discussion with management, others required more lengthy negotiations, and access to resources. The project identification and planning phases of the Vanuatu Project were heavily informed by Action Research principles and practice.

The underpinning theoretical concepts outlined above, have primarily been sourced from management and organisational behaviour literature, the concept of project-based professional development was heavily informed by research and theories on the value of experiential and active learning. The work of Dewey (1938), Piaget (1962), Kolb (1984), and Schön (1983), endorse active and experiential learning. Dewey based his theory on 'learn by doing'. Piaget promoted play and the value of a non-threatening environment for learning. Kolb promoted a cycle of learning involving observation, review, and reflection on practice with the goal of continuous improvement. Schön advocated the benefits of reflecting on the outcome of an action from the perspective of what might be done better in the future.

The conversion of the ELF into a tangible, cardboard pinwheel consisting of two moving parts: a trilogy of excellence in leadership focusing on quality management, engagement and scholarship; and, a customised quality improvement cycle, which starts with 'Evaluate', and rotates through a quality assurance cycle of 'Improve', 'Plan' and 'Act' was influenced by the Piaget, Dewey and Brown (2010), who promoted the importance of 'play' and experiential active learning for growth and development.

6. A Description of the Profession Development Activities Delivered at Emalus Preliminary Workshops

Establishing a collaborative and friendly environment was an important feature of the professional development activities conducted at Emalus campus. Participation was voluntary. The face-to-face workshops were provided outside the teaching semester and presented in an informal and non-threatening way. Staff were also provided with a satchel containing learning artefacts including the Engaging Leadership Framework (ELF) pin wheel artefact, a large writing pad, coloured marker pens, sticky notes, paper clips, mentos lollies and other stationary items. They enjoyed these gifts and used them in their workshops and group activities which minimised the drain on campus stationary resources.

The workshops provided plenty of opportunities for individual, partner and group participation, interaction and reflection through ice-breaker activities, games and hands-on activities. Staff were made to feel comfortable and were never put on the spot or required to speak in front of the group, unless they volunteered.

An early workshop focused on quality-assurance models, in particular Bennett's ELF. Participants practised using the cardboard artefact, moving through the phases of: Evaluation - what does the data say? Improvement - what needs to be improve? Planning – what needs to be included in the plan? and Action – implementation of the plan.

Another foundational workshop presented information on 'learning models' and provided suggestions on ways participants could focus on and improve their learning. This was included in the professional development offerings to illustrate to staff, factors that enable learning, 'brain-friendly' learning strategies and factors that act as barriers to learning. The material for this workshop was informed by the work of Willis (2006) and Hardiman (2012) and the learning artefacts developed by Bennett (2008).

7. Project-Based Workshop Methodology

While there was no requirement for staff to attend these sessions, the project-based workshops attracted 54 staff from a range of academic and service areas across the main Emalus campus and outlying centres. Many of the staff had attended the previous workshop so it was possible to build upon their prior knowledge and experience. After some introductory fun activities designed to relax staff, they were asked to jot down on separate sticky notes, areas in their unit which they felt needed to be improved. They were then invited to mingle and find others in the workshop who identified similar issues or themes. The like stickers were posted together on the walls around the room and subsequent discussion identified the major themes. After further discussion on the various themes and subsets, 15 groups were formed, and members self-selected into one of the groups. The project topics and areas for improvement are listed in the Table 1.

Table 1 Project topics

1.	Co-ordinate Open Days across Emalus Campus and Centres.
2.	Reconceptualise Emalus Reception Area and build capability of reception staff to provide and expand the range of information and services offered to students and stakeholders at the first point of contact.
3.	Improve student academic performance across Emalus Campus and Centres by focusing upon effectiveness of student learning and assessment preparation and coordination of student academic support across all sites.
4.	Address ways to restructure the workflow the Pacific Island Legal Information Institute (PACLII) at Emalus Campus to cope with regular internet and electricity outages.
5.	Rethink cleaning service schedules and workflow to address staff lateness and provide a more even spread of availability of cleaning service throughout day.
6.	Ensure that cleaning staff have safe and timely access to cleaning products and chemical dispenser sets and appropriate training.
7.	Provide support and build capacity of staff required to step up to higher level positions due to long term absences or departures of staff.
8.	Develop strategies to support security staff to address health and safety issues resulting from students drinking on campus and causing disturbances and damage.
9.	Lead landscaping project to grow knowledge and skills of ground staff as well as improve outdoor environment for students and staff.
10.	Pursue upgrading Emalus's Aid Post to a Dispensary to improve equity of access to health services for all students.
11.	Review Human Resource policies with respect to performance expectations and recognition and celebration of outstanding performance.
12.	Review Emalus Campus and Centres Workforce Plan with respect to appropriateness of organisational structure (Organisational Chart) supervisory roles and the effectiveness of current staff skill-sets.
13.	Improve communication and information services across the Emalus Campus.

14.	Improve communication and service delivery, particularly delivery of supplies, to Emalus Centres.
15.	Implement quality improvement of administration and support services at Emalus Centres.

Some of the smaller projects consisted of a group of three to four staff while the larger projects had up to eight members. Once the team members and topics were agreed upon, each group was provided with a simple Project Planning template. The template required them to summarise the issue, to identify what needed to be improved, and to document the plan in terms of 'why', 'what', 'how', 'when', 'who' and 'where'.

8. Project-Based Plans

It was important to keep the preparation of the Project Plans (Table2) as simple as possible. Some of the issues identified in the projects were relatively easy to address while others were much more complex and required significant mentoring and support, especially when the proposed actions required approval from managers and access to resources.

Table 2 - Sample of a complete template

Co-ordinate Open Days across Emalus Campus and Centres	
Team leader	Provided
Email contact	Provided
Team members	Managers representing Emalus and four outlying
Why	To create a culture of continuous quality improvement across Emalus Campus and Centres that fosters a safe, equitable and positive learning environment and a collaborative and efficient workplace for students and staff, leading to a passion for life-long learning.
What	The aim of this project is to improve the coordination and planning for Open Day activities across the organisation, in particular Emalus Campus and Centres. The goal will be to provide quality Open Days at each site and to grow the number of enquires and enrolment of students at each location over the next three years.
How	The project will develop, implement and evaluate an Open Day Communication and Coordination Plan to ensure the timely distribution of marketing material, student course information and other resources required for Open Day, to all sites. A key component of the Project Plan will be a schedule of tele-conference meetings of Open Day coordinators from each site to discuss overall goals, themes and concerns.
When	The Project Plan will include a planning phase which commences at least 3 months prior to the Open Day and provides Centres with a timeline for delivery of budgets and resources.

Who	The Project Plan will be driven by the Campus and Centre Coordinators and the Open Day Committee.
Where	Initially, the Plan will be coordinated from the Emalus Campus. However, in future years thought may be given to the practicality of rotating the coordination to other sites.

9. Findings from the Project-Based Model for Building Organisational and Staff Capability in the Higher Education Sector

The Project Plans that were developed in this case study clearly demonstrate the value of bringing staff together in a safe and non-judgemental environment to discuss and reflect upon ways to improve workplace practices and processes. The 15 project plans all have merit and were based on a shared goal of improvement. A noticeable outcome from the workshops and project planning process was the increased collaboration within and across groups, and the willingness of individuals and groups to take ownership of addressing the issues that they identified. This concept of taking ownership and pride in work, harks back to the similar findings described decades ago by Deming (1993) and others when discussing strategies for transforming workplaces and empowering employees.

A review of available data on the Emalus's Website and Facebook, indicate that the project related to Coordination of Open Days across the Emalus campus and centres resulted in very positive outcomes. These websites feature several pictures of 2018, 2019 and 2020 Open Days, displaying attractive, co-ordinated marketing materials, recruitment activities, student stalls, enquiry desks and crowds of students. Facebook reports that **…** *Emalus Campus has reached a milestone this year having registered 1,023 new students. The total number of students to study at the campus in 2021 is 1,671. (2021 Emalus Campus Facebook).*

10. Impact of COVID-19 on Evaluation and Follow-Up of the Projects Outcomes

The vision for this case study was to follow up the outcomes of all the Projects in Vanuatu in 2020-2021. COVID-19 disrupted these plans as borders were closed and travel plans were put on hold. Whilst it would have been beneficial to follow up the projects further, using digital technologies the limited communication resources at the campus and across Vanuatu, including access to electricity, presented too many challenges.

The process of identifying areas for improvement and preparing project plans can be seen as a significant achievement towards building the capacity of the campus and the individual staff involved. Not only have staff gained knowledge on quality assurance processes and the importance of continuous improvement they have had hands-on experience planning, and in many cases, implementing project-based initiatives.

11. Recommendations

The introduction of professional development for university staff in a developing country requires a very gentle and authentic approach. The following recommendations are based on the principles of the methodology that was deployed:

Recommendation 1 – From the outset, focus on building a sense of trust and respect for the participants.

Recommendation 2 – Acknowledge and design the program to align with the local educational landscape and context.

Recommendation 3 – Reinforce that the purpose of the workshop(s) is to help them improve their working conditions and grow their knowledge and skills.

Recommendation 4 – Use activities and small group interactions to create an open and a non-threatening, sharing, learning environment.
Recommendation 5 - Foster engagement through achievable and realistic activities.
Recommendation 6 – Provide choice and scaffold the discussions and learning when prompted.
Recommendation 7 – Ensure that the project is identified and driven by the participants.
Recommendation 8 – Reduce the project plan to a simple template which identifies the key elements of: why, what, how, when, who, and where.
Recommendation 9 – Embed milestones, monitoring and evaluation phases into the project plan.
Recommendation 10 - Provide opportunities for participants to share and celebrate their success
Recommendation 11- Document case studies for application in other developing counties.
Recommendation 12 – Explore the viability of the project-based professional development model with UNESCO or foreign aid agencies in developed countries such as Australian and New Zealand.

12. Conclusion

The case study described in this paper demonstrates that project-based staff professional development, which is strategic, scaffolded and sustainable has several benefits for both the university and the individual staff. The sense of ownership and the opportunity to address authentic workplace issues and areas of underperformance, immediately captured the participants' interests. They welcomed the chance to put forward their suggestions for improvements. They reported that in the past they did not know how to initiate these discussions. The projects gave them the confidence and vehicle to voice and act on their ideas.

Staff also enjoyed exploring the links between theory and practice by using the ELF pinwheel tool, which they could physically turn through the phases of the quality cycle. The session on how the brain learns gave the participants a greater understanding of strategies for effective learning and generated extensive discussion amongst the staff, especially about strategies for remembering information and learning new tasks. Hopefully this interest in learning will be carried forward into developing a culture of life-long learning.

Unfortunately, the impact of the pandemic meant that in depth, follow-up and evaluation of the projects has been largely anecdotal. Hopefully, when international borders are re-opened, and travel is once again possible, more follow-up work with the participants will be possible. Several attempts have been made to re-engage with participants using digital formats, but the lack of technology and infrastructure in Vanuatu has proven to be a big barrier for ongoing engagement.

Nevertheless, the findings presented in this paper provide a strong endorsement for the use of project-based staff professional development to grow organisational and staff capability and a culture of engagement and improvement. The project-based model is easy to scale and can be applied to address small and large needs across an organisation. The critical elements in its success appear to be developing a sense of trust and engagement with the participants, scaffolding and mentoring the plans and activities without micro-managing, providing the necessary resources including time and budgets, and most of all, recognising and celebrating the efforts of staff to make improvements to the workplace.

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14. References

Bennett, L**.,** Tasker, C., & Whitton J. (2008). *Leading Excellence' a report on the 'Leadership for Implementing Improvements in the Learning and Teaching Quality Cycle.* ALTC Project. Monash University. http://www.olt.gov.au/resource-library?text=leading%20excellence

Bennett, L**.,** & Hempsall, K. (2010). *Leading Excellence-Application of the Engaging Leadership Framework (ELF) to new higher education sites and contexts. ALTC* Project. Surry Hills, New South Wales: Australian Learning and Teaching Council. ISBN 978-1-921856-10-5. http://www.olt.gov.au/project-leading-excellence-application-engaging-leadership-framework-monash-2009

Brown, S. (2010). *Play: how it shapes the brain, opens the imagination and invigorates the soul*. Scribe.

Cruickshank, M. (2003). Total Quality Management in the higher education sector: A literature review from an international and Australian perspective. *Total Quality Management & Business Excellence*, 14:10, 1159-1167, DOI: 10.1080/1478336032000107717

Deci, E., & Ryan, R. (1985). *Intrinsic motivation and self-determination in human behavior*. Plenum.

Deming, E. (1956). On the Use of Theory. *Industrial Quality Control*, XIII (1).

Deming, E. (1993). *The new economics for industry, government, education. 2nd* Edition**.** MIT.

Dewey, J. (1938). *Experience and Education*. The Kappa Delta Lecture Series. First Touchstone Edition 1997. Simon & Schuster Inc.

Emalus Campus Facebook. https://www.facebook.com/emalus2018live/

Fusch, D. (2018), Professional Development in Higher Education Survey. AI Academic Impressions. https://www.academicimpressions.com/wp-content/uploads/2018/06/pd-report-2017.pdf

Hardiman, M. (2012). *The Brain-Targeted Teaching Model for 21st-Century Schools*. Corwin.

Jacob W., Xiong, W & Ye, H. (2015) Professional development programmes at world-class universities. Palgrave Communications 1:15002 doi: 10.1057/palcomms.20152

Juran, J. Ed. (1995). *A History of Managing for Quality*. ASQ Press.

Kember, D., & Gow, L. (1992). Action research as a form of staff development in higher education. *High Educ* 23, 297–310. https://doi.org/10.1007/BF00145018

Koch, J., & Fisher, J. (1998). Higher education and total quality management. *Total Quality Management*, 9:8, 659-668, DOI: 10.1080/0954412988136

Kolb, D. (1984). *Experiential Learning: Experience as the Source of Learning and Development*. Prentice Hall.

Mayo, E. (1946). *The human problems of an industrial civilization***.** 2nd edition, Harvard University.

McGregor, D. (1985). The Human Side of Enterprise: 25th Anniversary Printing. McGraw-Hill, Inc.

McNiff, J. (2013). *Action Research Principles and Practice. 3rd Ed.* Routledge.

Moen, R., & Norman, C. (2009). The History of the PDCA Cycle. In Proceedings of the 7th ANQ Congress, Tokyo 2009.

Piaget, J. **(**1962). *Play, Dreams and Imitation in Childhood*. W. W. Norman & Company Inc.

Schön, D. (1983). The Reflective Practitioner: How professionals think in action. Temple Smith.

Taylor, F.W. (1911). The Principles of Scientific Management. The Norton Library.

University of New Sales Wales. *Sydney Self-paced Professional Learning Modules*. website https://www.teaching.unsw.edu.au/self-paced-professional-learning-modules.

Willis, J. (2006). *Research-based strategies to ignite student learning.* ASCD.

Exploring infusing graduateness in an introductory programming module in an ODeL environment

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Abstract
Graduateness is an elusive quality which students are expected to develop while doing a degree. It includes both cognitive and non-cognitive skills, but non-cognitive skills are seldom directly addressed in teaching. This paper presents a description of an exploratory endeavour to infuse certain aspects of graduateness in an introductory programming module in an ODeL environment. The aim was to support students in assuming responsibility for their own learning to elicit a positive effect on the drop-out rate and the pass rate for the module. Various measures were introduced, inter alia, weekly e-mail announcements to assist students with keeping up with the study programme, mastering the study material, and to introduce students to topics to sensitize them to 21st century skills and self-development. Some of the other measures implemented include introducing Microsoft Teams as an additional communication channel to encourage student engagement and requesting students to reflect. Covid-19 changed circumstances for both students and lecturer. It increased the pressure under which students studied as well as the way the exams were conducted. As a result, it is not possible to measure and confirm how effective these measures were in reducing the drop-out rate or improving the pass rate for the module. However, reflecting on the effect of the measures implemented revealed some valuable lessons for possible future research for developing graduateness in an ODeL environment, and confirm that a formal study is justified and will contribute to research on graduate attributes in higher education in SA.
Keywords: Graduateness, introductory programming, ODeL, 21st century skills, transactional distance, computing education

1. Introduction

Graduateness is a somewhat elusive quality students should develop while doing a degree. It is not clearly defined (Bitzer & Withering, 2020; Perraton, 1998) and institutions often provide their own definition to characterize their students (Kew, 2015; Makhanya, 2012). In general, graduateness refers to a collection of attributes, knowledge and skills that will allow students to be gainfully employed after graduation (Chetty, 2012). Graduateness includes both cognitive skills, i.e. subject-specific and discipline knowledge, and non-cognitive social and emotional skills (Mentz et al., 2019). The latter is not necessarily embedded in university curricula (Bitzer & Withering, 2020). A broad description of graduateness is captured in the 21st century attributes and skills. The Assessment & Teaching of 21st Century Skills (ATC21S) project classified ten skills in four groups: thinking tactics (creativity and innovation, critical thinking problem-solving, decision-making, learning to learn/metacognition – understanding own thinking processes); working tactics (communication, cooperation or teamwork); working tools (information literacy, information and communication literacy) and behavior in the world (local and global citizenship, life and career, personal and social responsibility) (Binkley et al., 2014). The World Economic Forum (WEF) in turn identifies sixteen 21st century skills grouped in three clusters: basic literacies (applying fundamental skills in daily life: literacy, numeracy, scientific literacy, ICT literacy, cultural and civic literacy); capabilities (approaching complicated tasks: critical thinking/problem-solving, creativity, communication, collaboration) and personality traits (managing transforming environs: curiosity, initiative, persistence/grit, adaptability, leadership, social and cultural awareness) (Soffel, 2016).

Generic graduate attributes identified by universities do not always correspond or overlap with the graduate attributes required by professions (Elatia et al., 2021). The Washington accord specifies

graduate attributes for engineers (Alliance International Engineering, 2021) and various studies investigated graduate attributes expected by professional and regulatory bodies in ICT (Exter et al., 2018; Frank & Salem, 2018; Frezza et al., 2020; Osmani et al., 2018). Employers frequently consider soft skills to be more important (Kew, 2015) which require more focus on non-cognitive social and emotional skills. Self-management is a common trait in the required graduate attributes, and Roepen (2017) identified it as the most important skill in the workplace for recent graduates. Self-management refers to the ability to work independently and manage one's own time, work, objectives and career (Coetzee, 2012). This involves accepting responsibility for own learning and development and requires persistence. The IT industry, in particular, place much emphasis on life-long learning (Cox et al., 2013; Exter et al., 2018), and although graduate attributes for IT have not yet been clarified (Frezza et al., 2020), there is general agreement that most of non-technical skills are not covered well in computing undergraduate programs (Exter et al., 2018).

It is not easy to include the non-cognitive aspects of graduateness in teaching (Green et al., 2009; Kew, 2015). Bitzer and Withering's 2020 study on student perceptions of graduate attributes and the development thereof, highlights both the importance of students taking responsibility for developing graduateness and lecturers' role in this process. Students have to be active participants in developing their graduate attributes (Bitzer & Withering, 2020). It is probably more difficult to develop graduate attributes in distance education, where 'distance' not only refers to physical distance between students and institution, but also involve time, economic, social, educational, epistomological and communication differences (Heydenrych & Prinsloo, 2010). This 'transactional distance' (Moore, 2013) must be overcome by lecturers, students and the institution to enable effective learning. Open Distance e-Learning (ODeL) aims to overcome the differences by providing all teaching and learning material in digital format. Nevertheless, the transactional distance (Moore, 2013) caused by the differences remains a very real factor in an ODeL environment.

The transactional distance can be alleviated somewhat by creating a supportive and caring environment, fostering a sense of community as care and empathy provide affective proximity (Bozkurt & Sharma, 2021) . This can assist in developing positive attitudes and prosocial behavior in students (Nyysti & Walters, 2018) and would help to develop some of the social-emotional skills required for both academic and professional success (Levin, 2013; Liu & Huang, 2017). This corresponds with the role of social interaction in Vygotsky's Schoema (1979) theoretical framework of learning.

Social presence of the lecturer (Aragon, 2003; X. Liu et al., 2007) encourages higher levels of engagement and promotes a sense of community, which in turn improves students' academic performance (X. Liu et al., 2007). Unfortunately, computing students are amongst the most reluctant to engage (Morgan et al., 2018).The non-cognitive skills, i.e. the attitudes and behavior, can have a significant impact on a student's success in a distance learning environment. In SA there is a dearth of research into graduate attributes at higher institutions due to the high work pressure, lack of resources in higher education and pressure to raise the student throughput (Bitzer & Withering, 2020). Introductory programming modules are frequently viewed as high-risk modules with a low pass rate and a high dropout rate. Being a module leader for such a module, the author introduced various measures particularly aimed at encouraging students to take responsibility for their own learning, arguing that developing the skill of self-management which includes accepting responsibility for oneself will benefit students in the long term and should also have a positive effect on the module throughput. This paper reports on the measures implemented and provide some preliminary thoughts on the possible effect thereof. Related work is discussed section 2. In section 3, the background to the module is provided, while the measures are described in section 4. A reflection on the effect of these measures follows in section 5, with the conclusion in section 6.

2. Related Work

2.1 Developing Soft Skills

Various methods are used to develop soft skills in the IT environment. Commonly used methods include problem-based learning (Deep et al., 2019; Osmani et al., 2018), work-integrated learning (Redelinghuis & Drevin, 2019), project-based learning (Frank & Salem, 2018; Janse van Rensburg & Goede, 2019), apprenticeships (Taylor-Smith et al., 2019), collaborative learning (Osmani et al., 2018) and capstone projects (Stern et al., 2021). Few of these methods are suitable for first-year students in ODeL.

2.2 Student Reflection

Reflective writing enhances analytical and problem-solving skills by developing critical thinking. It can also encourage self-awareness, assist in developing grit and self-confidence and support intra- as well as interpersonal communication skills (Deveci & Wyatt, 2021). Dorochi et al. (2019) combine multiple reflections in an active learning classroom model with learning analytics to identify at-risk students, while Susler and Babacan (2021) use critical reflection combined with other pedagogical techniques to develop students' resilience. Janse van Rensburg and Goede (2019) embed reflection in problem-based learning for a second-year module in a four-year IT extended degree.

3. Background

The first level introductory programming module is offered at a large open distance education institution. When the measures to infuse graduateness were first implemented in 2020, it was offered as a semester module, but since 2021 it is offered as year module. While offered as a semester module, 600 to 700 students registered per semester. Currently approximately 1600 students are registered for the module. Students have diverse backgrounds, ranging from having no programming experience to being programmers who just want to obtain a qualification. Teaching in an ODeL environment uses a learning management system (LMS) with various options to engage students and to provide study material to students, while each student is also allocated to an e-tutor. An online Discussion Forum and Additional Resources folder are also provided on the LMS. The first tutorial letter usually provides all the assignments. In the semester system two assignments had to be submitted per semester, while a third assignment was intended only for self-assessment due to the time constraints. Since offering the module as a year module, four assignments have to be submitted. Teaching introductory programming in an ODeL environment poses various problems which results in a lower than desirable pass rate, and a high dropout rate. These include a lack of engagement from students with the lecturer and e-tutors, and probably each other too. Students often do not submit all assignments or start working on assignments too late. This creates a market for selling solutions to assignments online, a recurring problem. Providing all assignments in the first tutorial letter makes it easy to prepare solutions to assignments and offer it for sale online.

4. Measures Implemented

Various measures were implemented to counter these problems and foster a sense of a caring community. These include the following:

4.1 Weekly Email Announcement

The purpose of announcements in the LMS is to alert students to urgent matters. The weekly e-mail announcements are intended to help students stay on track with the study programme by reminding them what study material should be covered during the following week and of due dates for assignments. Additional notes on concepts students find difficult are included in the e-mail when the topic should be studied and are also available under the Additional Resources folder in the LMS.

Students are constantly encouraged to persevere and to contact their e-tutors or the lecturer should they need assistance. They are assured that it is OK and necessary to struggle to master the study material, and to share their knowledge with others. The difficult situations in which we are living is acknowledged and students are encouraged to look after their mental health and take enough rest. Importantly, the weekly e-mail announcements are used to communicate a selection of other topics to sensitize students to skills required as part of graduateness and to encourage them to develop these skills. All the information on the topics are summarized, with references and links should students care to investigate further. Providing references models the ethical digital behavior expected from students and responsible citizens (Tucker, 2014). In addition to the alerts to due dates and study material released, the topics covered in the weekly e-mails can be classified broadly into three categories:

- assistance provided by the university
- guidance related to the module itself
- material intended to foster the development of graduateness.

4.1.1 Assistance Provided by the University

The topics addressed in the weekly e-mails include an initial request to reflect on what they expect to gain from the module for their career, and a referral to the Directorate for Counselling and Career Development for career, academic and personal assistance and advice. Students are referred to the First-Year Experience (FYE) MOOCS and virtual student orientation offered by the institution to familiarize new students with online learning and the online environment, as well as broadcasts and videos by the Student Retention Unit on exam preparation and revision, and on writing online exams.

4.1.2 Guidance Related to the Module

Initial guidance related to the module itself explains how the module is run in the online environment, the purpose of announcements, the Lessons and Additional Resources, and the Microsoft Team for the module. Links to the prescribed book and software with videos showing how to install it are provided, as well as a study programme. The role of e-tutors is explained, and they are encouraged to seek assistance from their e-tutors. During the course of the semester or year practical guidance such as how to visualize CPU memory, plan a program, trace code to debug a program, things to try when you get stuck developing an algorithm or debugging, a check-list for solving programming problems, and tips on how to make code more readable are included. The importance of planning before coding is emphasized and students must submit their planning for some questions in the assignments. In preparation for the online exam students can take a mock exam for the module to familiarize themselves with the system. A tutorial letter with information on the format of the exam is distributed with a recording on common misconceptions and mistakes made in past exams. A checklist to assist in preparing for the exam as well as some advice on how to stay calm during the exam are also provided.

4.1.3 Material to Foster Graduateness

The material intended to foster graduateness commences with an introduction to the concept of ‘deep work’ as defined by Prof Cal Newport, a computer science professor at Georgetown University in Washington. ‘Learning something complex like computer programming requires intense uninterrupted concentrating on cognitively demanding concepts’ (Newport, 2016). ‘Deep work’ is defined as ‘Professional activities performed in a state of distraction-free concentration that push your cognitive capabilities to their limit. These efforts create new value, improve your skill, and are hard to replicate.’ This sets the scene for information on why deep work matters (the flow it creates produces its own rewards (Newport, 2016)), how to how to eliminate distractions to improve one’s focus (Rock, 2009), how attention shapes the quality of life (Gallagher, 2009) and deliberate practice (Beilock,

2015; Duckworth, 2016). In turn this leads to requesting students to plan how to carve out 8 hours per week to study for the module. Throughout the duration of the module students are then periodically reminded about deep work and focus, using quotes from inter alia James Clear, author of Atomic Habits (Clear, 2019). Ways to apply deliberate practice are also recommended. Bloom's taxonomy (Krathwohl, 2002) is presented to the students with links to websites where they can explore it further. This is followed by an explanation of how programming involves being able to apply knowledge that they understand and some guidance on how to ensure that they indeed know and understand the study material when they write code.

Students are made aware of three learning strategies from the work done by Prof Nate Kornell (https://sites.williams.edu/nk2/) and shown ways to put this into practice for the module linking it to deliberate practice of the study material. The 21st century skills and the importance of developing these skills, as well the 21st century skills they can develop in the module are pointed out. The concept of computational thinking is explained, and students are encouraged to play the AutoThinking game (https://www.autothinking.ut.ee/) to develop their computational skills. This game is specifically developed for this purpose. Material on reflection and the effect it can have on students' results as well as how to reflect are presented - more detail about that in section 3.3.

4.2 Providing Assignment Questions Gradually

Instead of providing all the assignments in the first tutorial letter, assignment questions are now distributed when a topic should be studied according to the study programme provided. The additional notes on the topic are distributed at the same time, although it is always available under Additional Resources on the LMS should students wish to work at their own pace. Students can then do the questions on a topic or concept as soon as they have studied it and so gain a deeper understanding and practice the skill they must develop. This also makes it more difficult to purchase an online solution to submit.

4.3 Student Reflection

The very first weekly e-mail requests students to reflect on the skills and knowledge required for their career they expect to gain from the module. Should they need assistance, they are referred to the Directorate for Counselling and Career Development. Reflection is introduced as a way to study more effectively by providing a link to a field experiment in which some students were asked to reflect on how they expect to perform in a test ten days later, why and what they can do to improve their marks, while the control group were just reminded about the upcoming test. Amazingly all those who thought (reflected) about their studies, did better than those who were only reminded about it (https://qz.com/978273/a-stanford-professors-15-minute-study-hack-improves-test-grades-by-a-third-of-a-grade/). Students are referred to an activity to explain how to reflect (https://www.open.edu/openlearn) and also provided with an infographic on reflection as a visual representation of the process. In addition to the initial reflection on the contribution of the knowledge and skills they will gain in this module to their career, students are required to reflect on their experience of doing each assignment. This is included as the last question in each assignment and marked to encourage students to do it. Before the examination, students are also encouraged to reflect on what mark they expect in the examination, what questions they expect would be asked, how they can prepare for it, what topics or concepts they still have not mastered and what they need to do to master it. After the exam, students are asked to provide feedback on their experience of doing the module.

4.4 Whatsapp Group

Students frequently use the Discussion Forum in the LMS to start a Whatsapp group for the module. The author joined this group.

4.5 Microsoft Teams

A Microsoft Team for the module to which all students are added provides space for students to interact with each other, the lecturer, and the e-tutors. The e-tutors also provide weekly lectures in the team for the module.

5. Reflection

The initial motivation for the attempts to infuse graduateness in the module was to improve the pass rate. It was hoped that by encouraging student engagement and making students aware of their own role in taking responsibility for developing their graduateness, together with a number of measures to assist them in keeping to a study programme that would allow them to cover all the study material with time for revision, would have a positive effect on the pass rate of the module.

Due to the onset of the Covid pandemic, the situation changed substantially. Lockdown commenced. Staff and students had to start working from home. Circumstances differed, but in most cases the result was additional pressure, for various reasons. Students studied under a lot more pressure than before. Even in an ODeL institution the pandemic and resulting lockdown caused significant changes and disruption in the way we were operating. Due dates for assignments were extended, exam dates moved, and the study programme had to be adapted accordingly. Contracts for external markers could not be finalized and processed to allow markers to mark assignments. This meant the lecturer now had to mark two assignments each for approximately 600 students within a short period. Fortunately, assignments are submitted online, and marking is done online. Exams now had to be written online, too, instead of being a written exam as in the past. This was a first for all of us. Since the circumstances changed so drastically, it is not possible to compare pass rates or to measure and confirm how effective the measures were in reducing the drop-out rate. Reflecting on the effect of the measures based both on the author's observations and feedback provided by students after the exam provides some insight.

Marking all the assignments, provided the opportunity to read the reflections of all the students who did it. Although not all students reflected, this was a remarkable experience providing insight into individual students' circumstances. Feedback was provided on every student's reflection, even if it was only to say: "Thank you for reflecting". Recurring themes in the reflections are how much it helps to plan a program before coding it, time management and the need to study consistently, characteristics that the measures are envisioned to develop. These themes were shared in a weekly e-mail. One student captured the intended gains from reflection very eloquently and generously gave permission to share this with his classmates. After the exam, several students enquired how they can see why and where they lost marks in the exam. Most of these students' marks were higher than 80%. This is evidence of their reflection on what mark they expected in the exam and how to achieve it.

Providing assignment questions on a weekly basis had a positive effect on students completing Assignment 3. Since the third assignment was for self-assessment in the semester system, students frequently did not attempt it and only looked at the solution. As a result, very few queries on Assignment 3 was received. Once the questions for Assignment 3 was distributed weekly, the queries on Assignment 3 rose significantly. As to solutions for sale online, it was still available, but frequently the solution was not applicable to the assignment the students had to submit. Student engagement certainly improved. Students engaged much more in the Microsoft team with both the lecturer and each other than previously on the Discussion Forum in the LMS. The reluctance to engage in the Discussion Forum in the LMS could partly be due to the cumbersomeness as up to six steps are required to post a message. Activating the notifications for the team allows quicker responses than

on the Discussion Forum. Queries on the team can also be answered on a cell phone. The Whatsapp group provides further opportunity for quick feedback on queries.

This seems to have resulted in students experiencing the module as a caring and supportive environment. Students feel confident that the lecturer will respond, as one student said *"Even though this module is a bit tricky, it is a pleasure doing it knowing that we can ask for assistance and getting a response within an hour depending on the time of the day*". From another student: "*I think that everyone can agree that xxxx really cares about her students... She really wants to see us succeed!*" Students also feel free to provide negative feedback: "*Getting notes every week about how far behind or ahead I should be is a little depressing. …. For me it was depressing and annoying*."

The exam changed from a written exam to an online randomized multiple-choice exam for the first semester. Students were given an option to postpone their exam to the year-end exam. Nevertheless, the percentage of students absent from the exam was in line with that of the previous 5 years. Students also appeared to be putting in considerably more effort than usual, judging by the number of queries and the level of detail in the queries received from students before the exam. Though the increase in queries could be due to the new online format of the exam, it could possibly also be ascribed to an increased sense of responsibility on the students' side. As the multiple-choice exam resulted in unusually high marks, the format for the second semester combined multiple-choice and short answer questions, where students had to write code, which was marked manually online. This created a more accurate online assessment than multiple-choice questions only. It also revealed how difficult novices find programming and having to know subject terminology and understanding concepts before being able to apply it.

The ATC2IS 'ways of living in the world' (Binkley et al., 2014) and the character qualities identified in the sixteen 21st century skills identified by the WEF (Soffel, 2016), are probably best developed by mentoring or being modeled by a person in regular close contact. The weekly e-mails were an attempt to simulate such contact and to create a caring environment. The measures intended to foster graduateness, e.g. introducing the concepts of 'deep work', focus and eliminating distractions together with Bloom's taxonomy is an attempt to develop students' ways of thinking or meta-cognition from ATC21S. These measures encourage the development of character qualities such as persistence/grit listed in the 16 21st century skills, as well as self-management. Creating a Microsoft team for the module enhance the digital literacy skills of students who are not familiar with it and provide an opportunity to develop their communication and collaboration skills – the tools and ways of working described by the ATC21S, in line with the foundational literacy of the 16 21st century skills recommended by the WEF.

Reflecting develop self-management skills and urge students to assume responsibility for their career and personal development corresponding with behavior defined by the ATC21S. Character qualities such as curiosity, critical thinking, analytical and problem-solving skills, as well grit and self-confidence are also developed by reflection, while intra- as well as interpersonal communication skills are supported (Deveci & Wyatt, 2021). The student feedback and observations by the lecturer indicate that a formal study on the measures is justified.

6. Conclusion

This paper reports on several activities intended to cultivate graduateness as embodied by 21st century skills in an introductory programming module in an ODeL institution. The activities include weekly e-mails, gradual release of assignment questions, student reflections and additional communication channels. Due to the onset of the Covid-19 pandemic, conditions changed so much that it is not possible to use student performance to confirm the success of the measures.

Did the measures achieve the purpose it was intended for? The social presence of the lecturer (Aragon, 2003) and the affective proximity (Bozkurt & Sharma, 2021) created by a caring environment produced evidence, although subjective, that confirms a degree of success. Certainly, the author's perspective on students' circumstances was extended and the enhanced interaction with students led to greater job satisfaction, a very rewarding experience. The value of student reflection, a caring environment and the social presence of the lecturer are emphasized by this experience. The extent to which students' graduateness will develop by these measures, will differ and depend on each student's effort and situation.

There is a lack of research into graduate attributes at higher institutions in SA (Bitzer & Withering, 2020). The research on developing graduate attributes in undergraduate computing qualifications are mostly aimed at final year students, and research on developing graduate attributes in first-year computing students can alleviate the lack of research into graduate attributes at higher institutions in SA. Future research comprises a formal study to investigate the association between reflection, development of graduate attributes and academic performance as well as between attributes and academic performance. This includes a qualitative study on students' experience of the measures and which of them are the most effective. A longitudinal study on the progress of students in an online environment who reflect may also deliver interesting outcomes.

7. References

Alliance International Engineering. (2021). *INTERNATIONAL ENGINEERING ALLIANCE GRADUATE ATTRIBUTES & PROFESSIONAL COMPETENCIES*. https://www.ieagreements.org/assets/Uploads/IEA-Graduate-Attributes-and-Professional-Competencies-2021.1-Sept-2021.pdf

Aragon, S. R. (2003). Creating social presence in online environments. *New Directions for Adult and Continuing Education*, *2003*(100), 57–68. https://doi.org/10.1002/ACE.119

Beilock, S. (2015). *How the Body Knows its Mind*. Robinson.

Binkley, M., Erstad, O., Herman, J., Raizen, S., Ripley, M., Miller-Ricci, M., & Rumble, M. (2014). Defining twenty-first century skills. In *Assessment and teaching of 21st century skills*. https://doi.org/10.1007/978-94-007-2324-5_2

Bitzer, E., & Withering, M. (2020). Graduate attributes: How some university students experience and learn them. *South African Journal of Higher Education*, *34*(3), 13–31. https://doi.org/10.20853/34-3-3504

Bozkurt, A., & Sharma, R. C. (2021). On the verge of a new renaissance: Care and empathy oriented, human-centered pandemic pedagogy | Asian Journal of Distance Education. *Asian Journal of Distance Education*, *16*(1), i–vii. http://asianjde.com/ojs/index.php/AsianJDE/article/view/576

Chetty, Y. (2012). Developing student graduateness and employability: Issues, provocations, theory and practical application. In M. Coetzee, J.-A. Botha, N. Eccles, H. Nienaber, & N. Holtzhausen (Eds.), *Developing student graduateness and employability: Issues, provocations, theory and practical application* (pp. 5–24). Knowres Publishing.

Clear, J. (2019). *Atomic Habits: An Easy & Proven Way to Build Good Habits & Break Bad Ones*. Avery.

Coetzee, M. (2012). A Framework for Developing Student Graduateness and Employability in the Economic and Management Sciences at the University Of South Africa. In M. Coetzee, J.-A. Botha, N. Eccles, H. Nienaber, & N. Holtzhausen (Eds.), *Developing student graduateness and employability* (pp. 119–152). Knowres Publishing.

Cox, A. M., al Daoud, M., & Rudd, S. (2013). Information management graduates' accounts of their employability: A case study from the university of Sheffield. *Education for Information*, *30*(1–2), 41–61.

Deep, S., Salleh, B. M., & Othman, H. (2019). Study on problem-based learning towards improving soft skills of students in effective communication class. *International Journal of Innovation and Learning*, *25*(1), 17. https://doi.org/10.1504/ijil.2019.10016630

Deveci, T., & Wyatt, M. (2021). Reflective writing and the self-perceived development of intrapersonal communication skills among first-year university students in the UAE. *Reflective Practice*. https://doi.org/10.1080/14623943.2021.1978066

Dorodchi, M., Benedict, A., Desai, D., Mahzoon, M. J., Macneil, S., & Dehbozorgi, N. (2019). Design and Implementation of an Activity-Based Introductory Computer Science Course (CS1) with Periodic Reflections Validated by Learning Analytics. *Proceedings - Frontiers in Education Conference, FIE*, *2018-Octob*. https://doi.org/10.1109/FIE.2018.8659196

Duckworth, A. (2016). *Grit: The Power of Passion and Perseverance*. Vermilion.

Elatia, S., Carey, J. P., Jamieson, M., Alibrahim, B., Carey, J. P., Jamieson, M., & Ivey, M. (2021). Intersecting Roadmaps: Resolving Tension Between Profession-Specific and University-Wide Graduate Attributes Intersecting Roadmaps: Resolving Tension Between Profession-Specific and University-Wide Graduate Attributes. *Canadian Journal of Higher Education*, *51*(1). https://doi.org/https://doi.org/10.47678/cjhe.vi0.188781

Exter, M., Caskurlu, S., & Fernandez, T. (2018). Comparing computing professionals' perceptions of importance of skills and knowledge on the job and coverage in undergraduate experiences. *ACM Transactions on Computing Education*, *18*(4). https://doi.org/10.1145/3218430

Frank, B., & Salem, D. (2018). *Enhancing Development of Competencies by Means of Continuous Improvement Processes*. https://doi.org/10.3138/cpp.2017-041

Frezza, S., Clear, T., & Clear, A. (2020). Unpacking Dispositions in the CC2020 Computing Curriculum Overview Report. *Proceedings - Frontiers in Education Conference, FIE*, *2020-Octob*(ii). https://doi.org/10.1109/FIE44824.2020.9273973

Gallagher, W. (2009). *Rapt: Attention and the Focused Life*. Penguin.

Green, W., Hammer, S., & Star, C. (2009). Facing up to the challenge: why is it so hard to develop graduate attributes? *Higher Education Research & Development*, *28*(1). https://doi.org/10.1080/07294360802444339

Heydenrych, J. F., & Prinsloo, P. (2010). Revisiting the five generations of distance education: Quo vadis? *Progressio*, *32*(1).

Janse van Rensburg, J. T., & Goede, R. (2019). Reflecting On The Use Of Project-Based Learning For 21st Century Competencies In an IT Extended Programme. In J. Kriek, A. Ferreira, K. Padayachee, S. van Putten, D. Mogashana, W. Rausher, H. Atagana, & M. Speight Vaughn (Eds.), *UNISA ISTE Conference on Mathematics, Science and Technology Education* (pp. 76–84). Unisa.

Kew, B. (2015). *A STUDY OF THE RELATIONSHIP BETWEEN STUDENTS' PARTICIPATION IN THE COMMERCE EDUCATION DEVELOPMENT UNIT AND THEIR GRADUATE ATTRIBUTES* .

Krathwohl, D. R. (2002). A Revision of Bloom' s Taxonomy: An Oveview. *Theory into Practice*, *41*(4), 212–219. https://doi.org/10.1207/s15430421tip4104

Levin, H. M. (2013). The utility and need for incorporating noncognitive skills into large-scale educational assessments. In *The Role of International Large-Scale Assessments: Perspectives from Technology, Economy, and Educational Research*. https://doi.org/10.1007/978-94-007-4629-9_5

Liu, M.-C., & Huang, Y.-M. (2017). The use of data science for education: The case of social-emotional learning. *Smart Learning Environments*, *4*(1). https://doi.org/10.1186/s40561-016-0040-4

Liu, X., Magjuka, R. J., Bonk, C. J., & Lee, S. (2007). Does Sense of Community Matter? An Examination of Participants' Perceptions of Building Learning Communities in Online Courses. *Quarterly Review of Distance Education*, *8*(1), 9–24.

Makhanya, M. (2012). Student graduateness. In M. Coetzee, J.-A. Botha, N. Eccles, H. Nienaber, & N. Holtzhausen (Eds.), *Developing student graduateness and employability: Issues, provocations, theory and practical application* (pp. 25–44). Knowres Publishing.

Mentz, J. C., Schoeman, M. A., & Loock, M. (2019). The Roles, Behaviors and Expectations of the Participants in the Development of Student Graduateness. *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, *11937 LNCS*. https://doi.org/10.1007/978-3-030-35343-8_47

Moore, M. G. (2013). The Theory of Transactional Distance. In M. G. Moore (Ed.), *Handbook of Distance Education* (3rd ed., pp. 66–85). Routledge.

Morgan, M., Sinclair, J., Butler, M., Thota, N., Fraser, J., Cross, G., & Jackova, J. (2018). Understanding international benchmarks on student engagement: Awareness and research alignment from a computer science perspective. *ITiCSE-WGR 2017 - Proceedings of the 2017 ITiCSE Conference on Working Group Reports*, *2018-January*. https://doi.org/10.1145/3174781.3174782

Newport, C. (2016). *Deep work: rules for focused success in a distracted world*. Piatkus.

Nyysti, K., & Walters, K. (2018). Out of Isolation. In A. G. Scheg & M. Shaw (Eds.), *Fostering Effective Student Communication in Online Graduate Courses*. IGI Global. https://doi.org/10.4018/978-1-5225-2682-7.ch010

Osmani, M., Hindi, N. M., & Weerakkody, V. (2018). Developing employability skills in information system graduates: Traditional vs. Innovative teaching methods. *International Journal of Information and Communication Technology Education*, *14*(2), 17–29. https://doi.org/10.4018/IJICTE.2018040102

Perraton, H. (1998). Open and distance learning: prospects and policy considerations. UNESCO, 1997. *Open Praxis: The Bulletin of the International Council for Distance Education*, *2*, 46-.

Redelinghuis, L., & Drevin, L. (2019). Student and manager perspectives on the graduate attributes of Information Technology (IT) students after Work-Integrated Learning (WIL). In J. Kriek, A. Ferreira, K. Padayachee, S. van Putten, D. Mogashana, W. Rausher, H. Atagana, & M. Speight Vaughn (Eds.), *UNISA ISTE Conference on Mathematics, Science and Technology Education* (pp. 229–236).

Rock, D. (2009). *Your Brain at Work*. HarperCollins.

Roepen, D. (2017). Australian business graduates' perceptions of non-technical skills within the workplace. *Education and Training*, *59*(5), 457–470. https://doi.org/10.1108/ET-01-2017-0016

Soffel, J. (2016). *What are the 21st-century skills every student needs?* https://akwl.org/wp-content/uploads/2016/01/21-century-skills-SEL-technology.pdf

Stern, E., Brewster, L., Naguib, J., Georges, M., Saccomano, J., Kelly, P. H., Tappert, C., & Leider, A. (2021). *Measuring the Value of Capstone Computing Projects*.

Susler, O., & Babacan, A. (2021). Embedding Graduate Resilience into Legal Education for a Disrupted 21st Century. *International Journal of Innovation, Creativity, and Change*, *15*(1), 18–33.

Taylor-Smith, E., Smith, S., Fabian, K., Berg, T., Meharg, D., & Varey, A. (2019). Bridging the digital skills gap: Are computing degree apprenticeships the answer? *Annual Conference on Innovation and Technology in Computer Science Education, ITiCSE*, 126–132. https://doi.org/10.1145/3304221.3319744

Tucker, S. Y. (2014). TRANSFORMING PEDAGOGIES: Integrating 21 ST Century Skills and Web 2.0 Technology. *Turkish Online Journal of Distance Education*.

Vygotsky, L. S. (1979). Mind in Society. The Development of Higher Psychological Processes. In M. Cole, V. John-Steiner, S. Scribner, E. Souberman, & J. v. Wertsch (Eds.), *The American Journal of Psychology* (Vol. 92, Issue 1). Harvard University Press. https://doi.org/10.2307/1421493

The Fourth Industrial Revolution as a fuel to higher education's accessibility in South Africa: challenges and opportunities

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Abstract
This paper analyses higher educational accessibility through the elements of the Fourth Industrial Revolution (4IR) in light of the challenges and opportunities brought by the 4IR in relation to higher educational accessibility. Accordingly, the paper draws its inspiration from the current discourse on the 4IR in South Africa. Some institutions of higher learning in South Africa, i.e., Universities of Pretoria, Johannesburg and Cape Town, have always enjoyed advantages of advanced modern technology. On the other hand, the so-called disadvantaged higher educational institutions, i.e., University of Limpopo, University of Venda and Lataba College, to name a few, are currently compelled to consider the use of 4IR technologies to provide and enhance education accessibility due to the Corona Virus (COVID-19) pandemic. The advent of the pandemic revealed that there is a wide gap between advantaged and disadvantaged South African institutions of higher learning in terms of education accessibility through 4IR tools. This paper attempts to theoretically close the gap in the literature on the accessibility of disadvantaged higher educational institutions through the application of the 4IR technologies and explore the attendant challenges and opportunities thereof. The elements of the 4IR considered in this paper include, amongst others, Internet of Things (IoT) and the 5G network, which are key enablers of accessibility to higher educations. This paper foregrounds the 4IR tools because the previous industrial revolutions did not have much influence on the accessibility of higher education in disadvantaged tertiary institutions in South Africa. This paper is a conceptual intervention and adopts an eclectic literature-based methodology to analyse theoretically the accessibility of higher education, with particular interest in the challenges and opportunities of the 4IR technologies in South Africa's higher education. The paper recommends that disadvantaged higher institutions of learning should divert from the old way of teaching and integrate the "new online teaching and learning" normal so that education could be accessible.
Keywords: Accessibility; Digital Learning; Fourth Industrial Revolution; Higher Education; Massive Open Online Courses; South Africa

1. Introduction

Cantona and Blom (2004: 1) proffer that education is "a pre-condition to achieve sustainable economic growth". The authors contend that access to higher education could influence and shape the direction of the country's economic growth and development. Access to education relies on a variety of factors, including the mode through which such education is offered. One such a mode is the digital platforms, i.e., Blackboard, Zoom, etc. These platforms are important to consider, especially in light of the current transition from traditional to digital learning in South African higher education. Hence, this paper provides an analysis of the Fourth Industrial Revolution (4IR) technologies as enablers of access to higher education in South Africa. It suffices to assert that, no one knows how the system of higher institutions of learning would look like in 2070 or 2090 in terms of technological developments. This is because technology is not static, but dynamic. Technological developments have a significant bearing on education provision and accessibility. This is why numerous researchers are currently examining the phenomenon of the 4IR in view of education institutions. Among such researchers are Harper and DeWaters (2008) and Demartini and Benussi (2017), who have raised awareness about the accessibility of higher education institutions through the World Wide Web (www). These authors reiterate that the websites are an interactive digital platform for students and facilitators of teaching and learning in that, they enable the users to download information or videos. This confirms up the

notion that higher education, among other things, is accessible through digital tools, such as those of the 4IR (Mauree-Narrainen & Chetti, 2020). Harper and DeWaters (2008); Demartini and Benussi (2017) reaffirm that web-based teaching and learning has an onus to ensure equal access to higher education because it is perceived as a civil commitment of students and lecturers. Hattangdi and Ghosh (2008) concur with Harper and DeWaters (2008) by suggesting that, the transformation of knowledge, skills and capabilities necessitates a shift in teaching and learning in the current system of education to a digitised system.

Internationally, countries such as India, China and the United States of America (USA) have put forward and integrated the 4IR technologies in their higher educational institutions. Oman higher education in India, has taken advantage and made use of the new learning management systems and IoT concurrently to continue their academic assessments (Jain & Jain, 2021). Oman higher education also adopted video conferencing as another way of delivering learning services (Jain & Jain, 2021). The Thai administration has adopted video conferencing to support online teaching and learning (Qureshi, Khan, Raza, Imran & Ismail, 2021). The use of 4IR technologies by institutions of higher learning across the globe can enhance the research status of their institutions (Mogaji & Jain, 2020). The University of Ghana has trained its staff and lecturers to host online classes and provided free data to sustain academic assessments (Padachi, Mauree-Narrainen & Boolaky, 2020). The Sakai online platform was adopted by the university to enable and facilitate online teaching and learning (Padachi et al., 2020). The Open University of Sudan has adopted the use of 4IR technologies in online teaching and learning (Padachi et al., 2020). Similarly, South African institutions of higher learning are also attempting to keep up with the modern technology to render educational services and programmes despite challenges such as poor ICT infrastructure, amongst others, particularly for disadvantaged higher educational institutions (Hattangdi and Ghosh, 2008).

Hattangdi and Ghosh (2008) contend that, to achieve such a transformation, the benefits of Information and Communication Technologies (ICT) should be integrated into the current system of higher education. The authors claim that the adoption of the ICT in higher institutions of learning would enable the flexibility of teaching and learning wherein, the students could easily access knowledge in a convenient manner. The present author concurs with the notions shared by the afore-cited authors and broadens the scope of discussion by identifying gaps in the literature on the use of 4IR tools in teaching and learning. Of particular interest in this paper is a poor or inadequate analysis of the 4IR innovative technologies such as the 5G network, digital learning tools and IoT, which are currently positioned as available tools to enable accessibility to teaching and learning in institutions of higher education in South Africa. Along with appreciating the current prominence of 4IR in fuelling accessibility to higher education, this paper also highlights the challenges and opportunities brought by 4IR in South Africa's institutions of higher learning.

2. Analysis of the Fourth Industrial Revolution (4IR)

The 4IR is a successor of the Third Industrial Revolution (3IR). The 4IR refers to the use of elements such as the IoT, robotics, Artificial Intelligence (AI), biotechnology, nanotechnology, 5G network, automation and Cyber-Physical Systems (CPS) (Schwab, 2016; Penprase, 2018). Any educational strategy for the 4IR should be based on the outcomes of the 3IR, which include the emergence of blended online and contact teaching, the reliable and faster integration of global video and audio as well as a wide range of automated education services (Penprase, 2018). Indeed, one cannot attempt to stop the headway of the current technology because it influences how people live, how businesses are run and how the government responds to it.

While the 4IR may be a petrifying phenomenon, its benefits cannot be ignored, be it in the business industry or educational sector. Such benefits include, enhancing the effectiveness and efficiency, ease the cost or load of work *inter alia* (Schwab, 2016). Meanwhile, Shava and Hofisi (2017), opine that

while the anticipated benefits of the 4IR, i.e., to enhance effectiveness and efficiency, it bears innumerable challenges. As the adage says, "*not all storms come to destroy, but some storms come to clear the way*". Equally, the pessimists of the 4IR may agree that the 4IR came to destroy, while the optimists of the 4IR may contend that the 4IR came to ease the cost of doing the work and enhance efficiency and effectiveness. Whilst observing the inception of the 4IR, Cann (2016) avers that if the 4IR is executed successfully, it could lead to a massive job loss. However, World Economic Forum (WEF) (2016), as cited in Shava and Hofisi (2016: 205), ascertains that approximately "2.1 million jobs will be created in sectors such as computer, architecture, mathematical and engineering to name a few". Notwithstanding, this paper comprehensively discusses the accessibility of higher education by using the elements and tools of the 4IR technologies. Penprase (2018: 220) highlights that a strong foundation of ethical reasoning, multicultural awareness, and rational reasoning would be another key needed for higher education under 4IR, allowing for careful and knowledgeable use of the rapidly growing technology. According to Halverson and Collins (2009: 18), "new technologies create learning opportunities that challenge the traditional practices of schools and colleges". The authors further indicate that new learning niches enable people of all ages to pursue learning on their own terms and people around the world are taking their education out of school and into homes, libraries, Internet cafes and workplaces where they can decide what they want to learn, when they want to learn and how they want to learn.

3. Accessibility of Higher Education Through the Fourth Industrial Revolution

Any country that does not invest heavily in higher education is risking and preventing economic growth and development. Therefore, an educated society ought to manoeuvre and overcome any socio-economic hardships. Hattangdi and Ghosh (2008) indicate that in countries such as India, education is deemed as a hub of knowledge. The authors further claim that in India, ICT is implemented in higher education with the "potential to bridge the digital divide". The Indian government successfully bridges this divide by ensuring that students easily access higher education through digital teaching and learning (Hattangdi & Ghosh, 2008). Acosta-Vargas, Acosta and Luján-Mora (2018) posit that universities should encourage using websites as a means to accessing higher education in Latin America. The authors indicate that the use of websites has influenced the lives of the people, which has become a focal and primary source of soliciting knowledge and information. South Africa cannot be left out of the conversation about accessing higher education using the 4IR technologies. The University of South Africa (UNISA), for example, has traditionally adopted the use of digital technologies to enable and facilitate teaching and learning between students and lecturers. Such an initiative by UNISA seems to have encouraged most universities in South Africa, including the University of Limpopo, Fort Hare University and University of Venda, which were used to contact/face-to-face teaching and learning, are now transitioning to digital learning.

4. Opportunities Created by the Fourth Industrial Revolution in Ensuring Higher Education's Accessibility

The recent developments of the 4IR cannot be side-lined because the 4IR defines and shapes how the institutions of higher learning should conduct their teaching and learning, as well as to be accessible to all people. Arasid, Abdullah, Wahyudin, Abdullah, Widiaty, Zakaria, Amelia and Juhana (2018) reiterate that the development of the websites is effective and effective because it supports e-learning for lecturers and students. One cannot be oblivious of the fact that the 4IR poses some challenges in higher education. However, there are great and potential opportunities that the 4IR brings to the higher education sector. Pityana (2009) proffers that distance teaching and learning is "technology-intensive". The author also adds that technology is not a "bandwidth", but a collection and integration of hardware and software platforms, including devices such as computers, laptops and smartphones. These elements enable smooth and effective student online learning. The next section discusses the opportunities brought by the 4IR in ensuring the accessibility of higher education.

4.1. The Relevance of the 5G Network in Improving Access to Digital Technologies to Access Higher Education

The 5G network is the fifth-era portable network; a worldwide remote norm that succeeds 1G, 2G, 3G and 4G networks. Gue (2019) says that the 5G network is the next 5th age of cell innovation, which will significantly speed up inclusion and responsiveness of distant networks, more fit to air or digital interface. The rollout of this network (5G) should, in the coming years be implemented at least in proximity to rural areas so that it becomes a comprehensive network that covers everyone. Therefore, the 5G network empowers another sort of network that is intended to connect every person digitally and everything together, including machines, articles, and gadgets (QUALCOMM. n.d). Its significance in ensuring access to higher education is inevitable. To be precise, the 5G network will facilitate and speed up connections from the learning devices such as laptops, computers and smartphones because students and lecturers will be able to connect to a faster and more convenient network. Subsequently, this would enable a smooth connection to e-learning and participation in the academic assessments with fewer network challenges. Hence, 5G as one of the 4IR digital tools is an efficient and effective intervention to ensure smooth or active connectivity of devices. TotorialsPoint (2021) affirms that the 5G network has the ability to "gather all networks in one platform". Karpersky (2020), who indicates that the 5G network connects more devices, also supports this stance. Karpersky (2020) further indicates that 5G is faster and more responsive. TutorialsPoint (2021) concurs by indicating that the 5G network is more efficient and effective. One can assert, in view of TutorialsPoint's and Karpersky's submissions, that, 5G network is one of the keys that can enable the provision of and access to online teaching and learning in institutions of higher learning.

4.2. Digital Teaching and Learning and Internet of Things

Digital teaching, learning, and IoT are part of the tools associated with the 4IR. Hence, digital teaching and learning have been adopted by countries such as China and India. Likewise, South Africa is also beginning to embrace such kind of digital learning. Reis, Barroso and Gonçalves (2013); Shahroom and Hussin (2018) proffer that students should be able to access teaching and learning using digital applications. The authors also posit that ICT is the main driver toward accessing higher education. Ngubane-Mokiwa and Letseka (2015) relate digital teaching and learning to E-learning, and further postulate that E-learning refers to the adoption and the use of electronic technologies to render and facilitate academic assessments from the students and their lecturers. According to Padachi et al. (2020: 71), the benefits of online learning include saving time, convenience, accessibility, saving the costs for transport, gaining access to recorded sessions and flexibility.

4.3. Open Distance Learning

Open Distance Learning (ODL) is a concept that emerged in order to ensure solace to preoccupied students and lecturers who see it as being flexible regardless of the physical environment (Towobola & Raimi, 2011). It is for this reason that Towobola and Raimi (2011) maintain the view that the ODL is a catalyst for education. Pityana (2009) argues that ODL is another type of rendering educational programmes and assessments with an intention to ameliorate limited and poor access to higher education. Pityana also adds that ODL is an effective and efficient educational model compared to the traditional teaching and learning (contact learning). For this reason, the ODL is slowly gaining momentum in South Africa through the use digital technologies. Towobola and Raimi (2011) reveals that the ODL is being implemented in institutions such as the University of Leicester in the United Kingdom (UK), University of South Africa (UNISA) and University of Pretoria (UP) to facilitate their programmes through distance learning. Jena (2020) asserts that digital learning is transparent and enhances the accessibility of higher education. One concurs with Jena but annotates that the ODL is facilitated by the current emergence of digital tools such as Zoom, Google meet, Skype, WhatsApp, Telegrams, Blackboards and Microsoft teams, amongst others. Therefore, the key to smooth learning and teaching is access to the network, which perhaps the 5G network is anticipated to provide in the next few years. Additionally, higher institutions of learning, which are normally referred to as

previously disadvantaged in South Africa, are beginning to adopt digital learning tools and to integrate ODL in their teaching and learning processes. Hence, the government, private sector and higher learning institutions in South Africa need to ensure a successful implementation of the ODL by providing learning gadgets such as laptops and data to students.

5. Challenges of the Fourth Industrial Revolution in Higher Teaching and Learning

5.1. Students' Challenges

Notwithstanding the much-expected opportunities of the 4IR digital technologies in accessing higher educational institutions, there are some challenges that could affect the progress of students in learning. Towobola and Raimi (2011) state that one of the challenges is family disruptions. Students who reside in families that are overcrowded appear to be the victims of disruptions because of the noise levels and being sent to run some households' errands and domestic chores. Additionally, Dzakiria (2004) attests that some students find it difficult to learn and understand through e-learning, as they are used to the traditional learning (contact learning). According to Dzakiria (2004), what exacerbates the situation of learning from home is poor support from the family. This also foregrounds the point that an environment where there are family quarrels and challenges is not conducive for student learning. A study by Towobola and Raimi (2011) reveals that accessing higher education digitally (through ODL) has a negative impact on students with special needs, especially those students who have never been exposed to digital tools of learning. For example, Perales-Jarillo, Pedraza, Moreno-Ger and Bocos (2019) indicate that students who are suffering from blindness will be affected greatly by this mode of teaching and learning. Furthermore, students who are deaf cannot hear the lecture taking place, the blind cannot see, those without arms will also struggle, which will result in poor academic performance. Moreover, Padachi et al (2020: 71) found that 67% of students had challenges with connecting to the internet due to poor network coverage. Mogaji and Jain (2020) add that some students have no electricity and therefore cannot fully participate in online learning.

Hattangdi and Ghosh (2008: 10); Padachi et al. (2020: 72) summarise the challenges of technology in higher teaching and learning in South Africa by stating that:

- it would create digital inequality amongst students, where the privileged students who are well acquainted with digital tools would reap more benefits than the students without or with a poor background of using digital technologies.
- training for both students and lecturers would be required on how to operate certain software and hardware applications.
- there would be a great potential of copy and paste (plagiarism), which would threaten the quality of academic assessments.
- the cost of purchasing software and hardware could be exorbitant.
- digital learning weakens the bonding session between students and lecturers.
- there would be breakdowns of the laptop and smartphones.
- there would be times when there is no electricity at home.
- there would be technical predicaments in submitting the assessments online.

5.2. Higher Educational Challenges

While the University of South Africa is perceived as the champion of ODL and being at the forefront of using technology to deliver their teaching and learning, some disadvantaged universities such as the University of Limpopo, Forth Hare University and Letaba College are still behind in terms of technology development and usage. Jena (2020) observes that some of the institutions of higher learning in India are not equipped to shift from traditional teaching to digital teaching. In a study conducted by Mogaji and Jaina (2020), it was noted that Nigerian higher education institutions are facing the shortfalls of power supply (electricity), which makes it hard to adopt and conduct online learning. Hence, the inability and slow rollout of the digital teaching platforms in these institutions was exposed by the

COVID-19 pandemic. However, some institutions such as the University of Limpopo and University of Venda have attempted to enhance their ICT infrastructure and at least migrate to ODL. Qureshi, Khan, Raza, Imran and Ismail (2021) regard this migration as a mobile education that enables the accessibility of higher education in a more convenient manner.

6. Research Methodology

6.1. Research Instrument

The paper adopted a literature-based methodology. The methodology was selected because it enabled the researcher to rigorously peruse through literature and get into the practical details of the views of different scholars regarding the subject under investigation. The methodology, therefore, allowed the researcher to analyse, conceptualise the subject under investigation, and draw necessary inferences. In principle, the methodology focused on explanations, concepts, understanding and socially produced conditions (Pinto, 2010). This is just to emphasise that the approach was used throughout the methodological forte of this paper. The methodology also described how the paper's purpose was accomplished in terms of the ultimate research outcome, which is through a review of the literature.

6.2. Data Collection

Data collection entails the process through which the researcher collects data for a specific study. Data collection includes what, how, where, with who and when was data collected (Du Plooy, 2017). Therefore, in this paper, data was collected through the desktop study (literature review). Literature was collected or found in books, journal articles and reports to fulfil the purpose of the paper.

6.3. Data Analysis

Literature information was then analysed by adopting a content analysis technique. Content analysis is a popular method of analysing literature or textual data. Content analysis enabled the researcher to read, understand and develop themes and such themes were critically conceptualised and discussed.

7. Discussion

The effectiveness and profitability of higher education systems can be improved by adopting the 4IR technologies for both the students and lecturers. This includes the use of online software, robot learning systems, electronic voting and other online monitoring systems. The 4IR technologies such as digital learning, the 5G network, IoT and AI, are at the forefront of enabling access to higher education institutions (Jain & Jain, 2021). This enablement of access should bear in mind that developing counties such as South Africa are populated by students who fall into the category of being poor, lack of financial resources and poor network connections in their rural areas. The researcher endorses Massive Open Online Courses (MOOCs) as one of the main drivers of the 4IR in higher education. MOOCs enable higher education systems to broaden access by reaching out to students' communities and enabling them to learn content from formal learning systems (Hew & Cheung, 2014). With MOOCs, students get the opportunity of experiencing formal learning that leads to acquiring good qualifications.

It is important to note that MOOCs are not stand-alone tools and therefore, need to be complemented with support services like mentoring or coaching through an online platform for it to be a success (Hew & Cheung, 2014; Jain & Jain, 2021). As the adoption of MOOCs is still in its infancy from some disadvantaged institutions of higher learning, it is important to note that even though quality assurance tools are used during the deployment phase, the success rate of MOOCs needs to be continuously monitored. The traditional teaching and learning process could be revolutionised by the current 4IR. This is because the 4IR has the potential to break through the barriers and challenges to education erected by geography and time, allowing for much greater access to lifelong learning. This means that the costs that the students were paying such as rent, food and other necessities of life

would be curtailed because they would pursue learning from the comfort of their area, that is, at home. Therefore, modern 4IR technologies have the power and ability to alter fundamentally people's perceptions of the institutions of higher education. Higher education institutions should embrace this 'new normal' in their teaching and learning processes.

8. Conclusion and Recommendations

Digital transformation in higher education plays a significant role in ensuring the accessibility of higher education institutions. Clearly, at the centre of accessing higher education in the 21st century is the application of the 4IR technologies in the higher education system. The literature reveals that the fuel to access higher education in the 21st century is by 4IR technologies. The literature also reveals that ODL is an effective model for higher education institutions to adapt and become more relevant to the current developments of innovative technology. Therefore, the paper recommends that the disadvantaged institutions of higher learning should adopt and use the 4IR technologies as one of the champions to respond to the 'new normal' of teaching and learning. Such institutions should be supported by both public and private sector to ensure the success of online learning by adopting 4IR technologies. However, this new trend and culture of digital learning can enable and sustain teaching and learning even in post COVID-19 context. Therefore, the paper concludes that the 4IR technologies condensed together fuel the accessibility of higher education particularly to the disadvantaged institutions.

9. References

Acosta-Vargas, P., Acosta, T. & Lujan-Mora, S. 2018. Challenges to assess accessibility in higher education websites: A comparative study of Latin America universities. *IEEE Access*, *6*, 36500-36508.

Arasid, W., Abdullah, A. G., Wahyudin, D., Abdullah, C. U., Widiaty, I., Zakaria, D., Amelia, N. & Juhana, A. 2018. An analysis of website accessibility in higher education in Indonesia based on wcag 2.0 guidelines. *In IOP Conference Series. Materials Science and Engineering*, 306(1): 102-130.

Cann, O. 2016. Five million jobs by 2020: The real challenge of the fourth industrial revolution. Available at:https://www.weforum.org/press/2016/01/five-million-jobs-by-2020-the-real-challenge-of-the-fourth-industrialrevolution (Accessed 20 June 2021).

Canton, E. J. & Blom, A. 2004. Can student loans improve accessibility to higher education and student performance? An impact study of the case of SOFES, Mexico. *An impact study of the case of SOFES, Mexico. World Bank Policy Research Working Paper*, 3425.

Cholin, V. S. 2005. Study of the application of information technology for effective access to resources in Indian university libraries. *The International Information & Library Review,* 37(3): 189-197

Dzakiria, H. 2004. *The teacher is always there but isn't": Distance learners' experiences & perspectives on distance learning at Universiti Utara Malaysi*a. Unpublished thesis.

Gue, D. 2019. 5G in Healthcare: 7 advantages & disadvantages for providers to know. Available at:https://hitconsultant.net/2019/07/18/5g-in-healthcare-7-advantages-disadvantages-for-providers-to-know/#.YKTCeaGxXIU (Accessed, 20 May 2021).

Halverson, A.C. & Collins, R. 2009. *Rethinking education in the age of technology*. New York: Teachers College, Columbia University.

Harper, K. A. & DeWaters, J. 2008. A quest for website accessibility in higher education institutions. *The Internet and Higher Education*, 11(3-4): 160-164.

Hattangdi, A. & Ghosh, A. 2008. Enhancing the quality and accessibility of higher education through the use of Information and Communication Technologies. In *International Conference on Emergent Missions, Resources, and the Geographic Locus in Strategy as a part of the 11th Annual Convention of the Strategic Management Forum (SMF),* 2011: 1-14.

Hew, K.F. & Cheung, W.S. 2014. Students 'and instructors' use of massive open online courses (MOOCs): Motivations and challenges. *Educational Research Review*, 12: 45-58.

Jain, V., & Jain, P. 2021. From Industry 4.0 to Education 4.0: acceptance and use of videoconferencing applications in higher education of Oman. *Journal of Applied Research in Higher Education*, 13(3): 1-20.

Jena, P.K. 2020. Impact of pandemic COVID-19 on education in India. *International Journal of Current Research*, 12(7): 12582-12586.

Karspersky. 2020. Is 5G technology dangerous? Pros and cons of 5G network. Available at: https://www.karspersky.co.za/resource-center/threats/5g-pros-and-cons (Accessed, 20 May 2021).

Mauree-Narrainen, D. & Chetti, M. R. 2020. Young learners' engagement in learning Bharatanatyam Online during COVID-19 Pandemic. *International Conference on Teaching, Assessment and Learning in the Digital Age, Conference Proceedings*: 48-61.

Mogaji, E. & Jain, V. 2020. Impact of the pandemic on higher education in emerging countries: emerging opportunities, challenges and research agenda. *Challenges and Research Agenda Working Papers.* Vol 2020 No 8: 79-91.

Ngubane-Mokiwa, S. & Letseka, M. 2015. Shift from open distance learning to open distance e-learning. *Open distance learning (ODL) in South Africa*, *129*.

Padachi, K., Mauree-Narrainen, D. & Boolaky, A. 2020. Attitudes and behavior of online learning amidst COVID-19 Pandemic: The case of social science students at the University of Technology, Mauritius. *International Conference on Teaching, Assessment and Learning in the Digital Age, Conference Proceedings*: 62-74.

Penprase, B.E. 2018. *The fourth industrial revolution and higher education*. In Higher education in the era of the fourth industrial revolution. Palgrave Macmillan: Singapore.

Perales-Jarillo, M., Pedraza, L., Moreno Ger, P. & Bocos, E. 2019. Challenges of online higher education in the face of the sustainability objectives of the United Nations: carbon footprint, accessibility and social inclusion. *Sustainability*, 11(20): 55-80.

Pinto, R. M. 2010. Encyclopedia of research design. *Mixed methods design. 813-819*.

Pityana, B. 2009. Open distance learning in the developing world: trends, progress and challenges. Keynote speech delivered on the occasion of the M-2009 23rd ICDE world conference on open learning and distance education, 'flexible education for all: open-global-innovative',

Maastricht, the Netherlands, 7-10.QUALCOMM. n.d. Everything you need to know about 5G. Available at: https://www.qualcomm.com/5g/what-is-5g (Accessed, 19 May 2021).

Qureshi, M. I., Khan, N., Raza, H., Imran, A. & Ismail, F. 2021. Digital technologies in education 4.0. does it enhance the effectiveness of learning? A systematic literature review. *International Journal of Interactive Mobile Technologies*, 15(4): 31-46.

Reis, A., Barroso, J. & Gonçalves, R. 2013. Supporting accessibility in higher education information systems. In *International Conference on Universal Access in Human-Computer Interaction*. Springer, Berlin, Heidelberg: 250-255.

Schwab, K. 2016. *The Fourth Industrial Revolution*, The World Economic Forum. Available at: http://www.weforum.org/pages/the-fourth-industrial-revolution-by-klaus-schwab (Accessed, 19 June 2021).

Shahroom, A. A. & Hussin, N. 2018. Industrial Revolution 4.0 and Education. *International Journal of Academic Research in Business and Social Sciences,* 8(9): 314-319.

Shava, E., & Hofisi, C. 2017. Challenges and opportunities for public administration in the fourth industrial revolution. *African Journal of Public Affairs*, 9(9): 203-215.

Towobola, W. L. & Raimi, L. 2011. Open Distance Learning (ODL): A catalyst for educational and entrepreneurship development in Nigeria. *Continental Journal of Education Research*, 4(3): 1-11.

TutorialsPoint. 2021. 5G - Advantages & Disadvantages. Available at : https://www.tutorialspoint.com/5g/5g_advantages_disadvantages.htm (Accessed, 19 May 2021).

World Economic Forum. 2016. *The future of jobs: Employment, skills and workforce strategy for the Fourth Industrial Revolution*. Available at: https://www.weforum.org/reports/the-future-of-jobs (Accessed 20 June 2021).

Perceptions on an extended programme in Computer Science at a South African University

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Abstract
Extended curriculum programmes (ECPs) were introduced at higher education institutions in South Africa to afford students not meeting the requirements of specific programmes the opportunity to improve their skills. North-West University introduced a BSc-IT ECP in 2010 to offer more students the opportunity to obtain an academic qualification in the field of Computer Science. This paper provides background on how ECPs were established in South Africa and a brief explanation of the structure of the BSc-IT ECP that was introduced at the North-West University. A qualitative research approach was conducted to gain an understanding of the perceptions of students and lecturers on the BSc-IT ECP. Data obtained during interviews were transcribed and analysed using content analysis. Themes included students' initial versus current perceptions of the BSc-IT ECP and challenges that they experienced during their studies. Lecturers' perceptions were obtained on positive and negative aspects contributing towards the success of the BSc-IT ECP. Data revealed that students and lecturers are predominantly positive about the BSc-IT ECP which provide students who would otherwise have been excluded, the opportunity to further their studies at a higher education institution in the field of Computer Science. Furthermore, the paper reports on factors regarded by participants to contribute towards the success of the BSc-IT ECP.
Keywords: Information Technology, Extended Curriculum Programme, Computer Science.

1. Introduction

In the fields of science, mathematics and technology, the gap between the level of skills and knowledge learners obtain during their school career and those required in higher education is a matter for concern. Ramma, Samy, Gopee, Roberts, and Roberts (2015) regard the "*gap*" between secondary and higher education as a lack of the development of critical thinking skills and creativity at school level. The authors report that in Mauritius creativity is hindered by a schooling system that is examination driven. Examination results are often dependent on rote learning which inhibits creativity and innovativeness (Ramma et al., 2015). As a result, students who are enrolled for higher education often encounter problems when they are required to apply knowledge associated with deep learning as demanded at the level of higher education in scientific fields of study (Steenkamp & Anghel, 2019). In addition, Sintema (2020) predicts that the gap between secondary and higher education in science, mathematics and technology will probably increase with the disruption in school programmes caused by the Covid-19 pandemic. ECPs could be implemented in these circumstances as these programmes have become a suitable way for higher education institutions to address the gap between secondary and higher education (Garraway, 2017).

ECPs are offered over a period of one year as an introduction to the specific programme the student is enrolled for (Garraway & Lange, 2020). A student enrolling for an ECP would therefore complete a standard three-year programme within four years. The additional first year of study contains a selection of modules on an introductory level as preparation for the following years of study comprising of standard programming modules. Since ECPs have been introduced, more learners have been provided the opportunity to further their studies at higher education institutions.

This research aims to report on the perceptions of students and lecturers on a BSc Information Technology (IT) ECP offered at the North-West University in South Africa, while focusing on factors contributing towards successfully presenting an ECP in Computer Science. The paper consists of four parts. First, it provides a literature review on ECPs and background information on this study. Then the research methodology is presented and data analysis procedure techniques are discussed. Next, the results are summarized. The paper concludes with a discussion of the results and the implications thereof.

2. Extended Programmes

In South Africa inadequate schooling was offered to black, coloured and Indian communities for many years in the apartheid-era (Garraway, 2017; Garraway & Lange, 2020; Smith, Case, & Van Walbeek, 2014). Therefore, the few students from these communities who were allowed to enrol at higher education institutions in South Africa found it difficult to complete their studies, specifically in the science-related fields (Grayson, 2010). Some intervention was required to improve the knowledge and skills of these students in order to meet the demands of higher education. As a result, bridging academic programmes emerged at higher education institutions in South Africa in the 1980s. These programmes were aimed to better equip students with the required knowledge and skills, providing them with an increased opportunity to cope with the demands of higher education in general (Case, Smith & Van Walbeek, 2014). The bridging programmes were referred to as academic support programmes. However, it was soon realized that these academic support programmes were too general and did not succeed in its purpose. The academic support programmes were therefore replaced by foundation programmes. Foundation programmes are defined as "*special programs for students whose prior learning has been adversely affected by educational or social inequalities*" [sic] (Kloot, Case & Marshall, 2008). Foundation programmes are aimed at improving knowledge and skills in specific fields of study. An example of one such foundation programme that was approved by the Department of Higher Education in South Africa is the Science Foundation Programme, developed by the University of Cape Town in 1986 (Kloot et al., 2008).

Arguments against bridging/foundation programmes include poor quality students who do not have the ability to excel at tertiary level are accepted while false expectations are created amongst students who attend these programmes (Hay & Morals, 2004). However, Hay and Morals (2004) published interesting results from their study on the implementation of one of these foundation programmes - the Career Preparation Programme (CPP) - for a period of 10 years (1992-1995) in the Bloemfontein region of the Free State province, South Africa. The CPP was developed as part of the Need for Education and Elevation (NEEDS) programme. After the successful completion of the CPP, students were allowed to pursue their studies at any higher education institution who recognized the CPP as a valid bridging programme. The duration of these foundation programmes is normally one year with no credit-bearing modules towards a programme (Grayson, 2010). In spite of many arguments opposed to the offering of bridging programmes, Hay and Morals (2004) report that 610 of the students who completed the CPP successfully over a period of 10 years, furthered their studies and obtained academic qualifications. Amongst these, a total of 43 students completed their honours degrees and one student did a Master's degree. Even though these figures amount to only 26% of the students who enrolled for the CPP over the reported period of time, it is still of value since 610 students who otherwise would not have obtained an academic qualification have done so. However, due to the low success rate of the implementation of these "add-on"-programmes, the National Department of Education instructed universities to rather develop and offer ECPs which provide a bridging phase for students to adapt and improve their skills in their specific field of study (Grayson, 2010; Makgobole & Onwubu, 2021).

3. Background

A need for an ECP in Computer Science was identified at the North-West University based on the fact that students who apply for enrolment in the standard BSc-IT programme often do not meet the minimum requirements. Also, students who do meet the minimum requirements often do not complete their BSc-IT programme in the minimum period of three years. During an exploratory study at the university on this phenomenon prior to the development of the BSc-IT ECP, BSc-IT senior students who failed to complete their studies within a period of three years admitted that they enrolled for the BSc-IT programme with the expectation to complete their studies in a period of at least four to five years. The students indicated that they found it particularly difficult to pass the mathematics and computer programming modules. The BSc-IT ECP extends the standard BSc-IT programme by one year, with the following modules presented during the first year of study, and during the first semester of the second year of study, as indicated in Table 1.

Table 1: BSc-IT Extended Modules

Year (semester)	BSc-IT extended module
Year 1(1)	Introduction to Problem Solving
Year 1(1)	Introduction to Mathematical Techniques 1
Year 1(2)	Introductory Programming Principles
Year 1(2)	Introduction to Mathematical Techniques 2.
Year 2(1)	Introduction to Graphical User Interface Programming
Year 2(1)	Introduction to Object Oriented Programming

In order to ensure the success of the BSc-IT ECP, there was a need to obtain insight into the perceptions of students and lecturers on the programme. In the next section the research methodology for the study is discussed.

4. Methodology

This study follows a qualitative research approach in the interpretivist paradigm in order to understand (Hay & Morals, 2004) the perceptions of students and lecturers about a BSc-IT ECP offered at a South African university. Students who were enrolled for the BSc-IT ECP and in their 2nd, 3rd or 4th year of study were invited to participate. Additionally, BSc-IT Honours students who completed the BSc-IT ECP were also invited. From the group of students who were invited, 13 students in their 3rd year of study, 4 students in their 4th B year of study and 3 students from the BSc-IT Honours programme accepted the invitation and participated in the study. The interview questions used for students from the BSc-IT ECP included:

1. "*What was your initial perception (feeling) about the BSc-IT extended programme when you were enrolled for the programme?*"
2. **"***What is your current perception on the BSc-IT extended programme after completing the first (extended) year of study?*"
3. "*What were the challenges you encountered in the BSc-IT extended programme, if any?*"
   "*Which, if any, BSc-IT extended programme modules did you find valuable? Why?*"

Lecturers who presented modules in the BSc-IT ECP at the North-West University over a period of 10 years were invited to participate in this study. Interviews were conducted with 6 lecturers who accepted the invitation. The questions during interviews for lecturers included:

1. "*What are the positive aspects of the BSc-IT extended programme in your opinion, if any?*"
2. "*What negative aspects of the BSc-IT extended programme can you identify, if any?*"
3. "*What are the most important factors in your opinion that contribute towards the success of a BSc-IT extended programme?*"

Conventional or undirected content analysis was used to analyse the data, which entails that the number of times a code was used was counted and codes were formed from the researchers' interests. More specifically, the process suggested by Zhang and Wildemuth (2009) was used and is provided in Table 2.

Table 2: Content analysis guidelines of Zhang and Wildemuth (2009) and its application.

Step	Description	Application to this study
1	Prepare the data	The interviews are transcribed and any personal information is removed.
2	Define the unit of analysis	Undirected content analysis is performed.
3	Develop categories and a coding scheme	Categorization of data through naming conventions in code as a result of undirected content analysis.
4	Test your coding scheme on a sample of text	Three interviews are coded.
5	Code all text	The remainder of the interviews are coded.
6	Assess the coding consistency	Using the new codes in Step 5, prior interviews are revisited and assessed for consistency. Codes that are related are grouped together to ensure consistency.

5. Students' Perceptions

The students' interviews were transcribed and coded and the various steps of Zhang and Wildemuth (2009) were followed. The following main themes and sub-themes were extracted from the study findings.

Theme 1: Initial perceptions on the BSc-IT ECP at the time of enrolment

Data collected on students' initial perceptions at the time of their enrolment were grouped according to the perceptions or feelings expressed towards the BSc-IT programme during the interviews, and revealed the following sub-themes:

a.) Excitement

Students who did not meet the minimum criteria for the standard BSc-IT programme expressed their excitement for the opportunity to study. Two students' responses were: "*I was excited because I could not qualify for straight programme because my marks didn't correspond. I regard the extended programme as a second chance*" [St-9], and "*No perception or feeling initially other than excitement for still being able to do a BSc-IT programme.*" [St-17].

b.) *Optimistic to improve knowledge and skills*

Some students with insufficient prior knowledge regarded enrolment for the ECP as a positive step towards the successful completion of their studies. One of the participants said "*I felt it would give me a better chance at learning more from scratch, learning the basics first.*" [St-5]. Another participant stated "*doing the extended programme was more of a relief because I had no tech/coding background*" [St-8].

c.) *Unsure/concerned about content*

Some students indicated that they did not know what the BSc-IT extended entailed: "*I did not actually have general knowledge about the extended programme*" [St-9] and "*I was more confused and worried especially when I heard that our modules were somehow different from the one of a straight IT."* [St 16].

d.) *Apprehensive about duration of study*

Some participants were not appreciative of the idea of having to study for an additional year. One of the participants mentioned "*The idea of spending an extra year did not sit well with me, but I said, okay let's do it since I did like IT*." [St-2]. Another participant said "*I did not know what it was all about and then they told me that it would be an extra year which kind of put me off but then I told myself I'm going to take the extra year its fine.*" [St-4].

Theme 2: Perceptions on the BSc-IT ECP at the time of the interview.
Students who participated in this study completed at least the first year of the programme (extended year). These students were at different year levels of completion of the programme at the time of the interview **(2nd, 3rd, 4th year of study or Honours)**. Responses to questions that were asked revealed the following sub-themes:

a.) Preparedness for entering the standard programme.

Most participants indicated that the ECP prepared them for the standard programme and improved their understanding of fundamental computer programming concepts. One of the participants responded by saying "*the extended programme helps the person prepare well enough to tackle the programming problems ahead through the entire IT programme.*" [St-2]. Another participant mentioned that "*I believe the extended programme was the best choice for me and a whole lot of other people who come from disadvantaged backgrounds, such as people who have not actually worked with a computer in their lives. This programme gave us a year to start familiarizing ourselves with how computers work and laid a solid foundation for algorithms. We learned how to think like a computer before we had to use it in practice and deal with debugging. It allows us to do some modules earlier and it takes away a lot of the pressure when we move towards later years of study.*" [St-18].

b.) Enjoyable.

Participants mentioned that the extended programme was enjoyable for them. To quote "*For me it was positive, I enjoyed it.*" [St-1].

c.) *Perform better in the standard programme than other students.*

Some participants indicated that they performed very well and sometimes better than standard programme students, for example: "*I was talking to my friends earlier on, and us extended students have a better understanding of programming in general*" [St-5], and "*I don't believe that other students in normal time-based programme saw any difference because at the end of the day, we became even wiser and catch up on things they already did.*" [St-8]. According to a participant, standard programme students have expressed that they would rather have completed the extended programme "S*ometimes students in the straight programme express that they should have done extended because you have this and we have not.*" [St-4].

Theme 3: Challenges experienced in the BSc-IT ECP.

Although many students shared the view that there were no challenges according to them, a few specific challenges were identified as sub-themes.

a) *Reluctance to ask questions.*

One of the participants indicated that he could not ask questions because it was expected of him to understand basic content although he did not. "*When I didn't understand I was afraid to ask the lecturer or friends because I felt like I'm failing to understand simple things*." [St-7].

b) *Programming is a difficult skill to master.*

One of the participants indicated that it was difficult to learn how to do programming, especially using Pseudocode: "*In the first year, first semester we completed a module in Pseudocode. As someone from a non-computer or coding background, I initially struggled to understand the concept of what was being taught*." [St-13].

c) *Time management.*

Time management was a challenge for a participant: "*Time management was one of the biggest challenges I have ever faced*." [St-10].

Theme 4: Valuable aspects of the BSc-IT ECP.

Aspects such as lecturing style, being well-prepared to adapt to the standard programme, and confidence were identified as sub-themes towards valuable aspects of the BSc-IT ECP.

a) *Lecturing style.*

Participants were of the opinion that lecturing style plays an important role in the following ways:
BSc-IT extended lecturers spend additional time on explaining concepts.
Participants were of the opinion that more time is spent on the basic concepts at a slower pace (this is also noticed in the excerpts in the next point): "*… in the BSc-IT extended programme, the lecturers start from the very basics and walk you into the world of IT",* [St-14] *and "… the extended course lecturer was patient with us and gave us opportunities to improve ourselves.*" [St-9].
Lecturers adapt the pace of work.
Participants noticed the change of working pace between the extended and standard programme with one participant pointing out that "*In the normal programme you really just have to catch up but in extended, they wait for you to catch up*." [St-8]. Another participant stated: "*There were very big differences especially in mathematics. At first the lecturer took it step by step and then when it got to the standard mathematics module it got quite complicated."* [St-4]. The noticeable change in pace of work between the extended and standard modules affected some students negatively while other students adapted well as can be seen in the next point.

b) *Adapting to the standard programme.*

The majority of participants indicated that the programme prepared them well to adapt to the standard programme, while a small number of participants still experienced the adaption as hard:
For example: "*I entered the main stream prepared*" [St-12], and "*I found that concepts explained in my second year would confuse my peers who were doing their first year, however for myself and the people who did the extended programme with me wouldn't struggle that much*" [St-18], were students finding it easier to adapt.
One student did not find it as easy to adapt due to the fast pace of work employed in the standard programme: *"I felt that the people in the normal course were better equipped to deal with the fast pace in the second year because they probably experienced it in their first year*." [St-2].

c) *Promoting confidence.*

Some participants indicated that they had more confidence after completing the BSc-IT ECP: "*It gave me a lot of confidence because I performed well,"* [St-5] *and* "*The way that the extended programme modules were taught made me comfortable to voice my opinion without being afraid of being wrong.*" [St-1].

d) ***Valuable module contents***

The perception of the majority of the participants was that the content of the extended year modules added value to their studies. "*I find all the modules that I did so far valuable because to date, I still go back to them to reference few things. They prepared us for mostly this year (3rd year)*" [St-8], and "*found all the modules to be valuable. Each one built on more knowledge and filled in the gaps from its predecessor, in a manner that made the learning process smooth.*" [St-13].

6. Lecturers' perceptions

The following main themes were identified and formulated as questions:

Theme 1: Positive aspects of the BSc-IT ECP.

Positive aspects of the ECP as perceived by lecturers revealed the following sub-themes:

a) *Opportunity to study*

Some lecturers mentioned that the BSc-IT ECP "*affords students with an opportunity to study"* [Lec-2]*, and "It provides an opportunity for students who did not meet the minimum requirements to enrol for the standard BSc-IT programme."* [Lec-1]

b) *Well-prepared for the standard programme*

The majority of lecturers mentioned that the good foundational knowledge and skills contained in the ECP assist students to adapt to the standard programme and advance to further studies. Some of the responses include "*Students are better prepared for the standard programme because the programme focuses on fundamental concepts and skills*" [Lec-1], and *"Students in the extended programme do a lot more problem-solving exercises and drills with guidance from the lecturer as with standard programme modules.*" [Lec-3].

c) *Teaching and learning conditions*

The pace of work and assistance from lecturers in mastering programming skills is a positive aspect: "*Students get special attention and lecturers tend to spend more time explaining the difficult concepts"* [Lec-5]*,* and *"Unlike the normal programme, students in the extended programme have enough time to learn and master the basics of programming with more assistance from lecturers*." [Lec-3].

d) *Maturity*

The lecturers mentioned that students are emotionally more mature after completing the first year of study in the ECP: "*it prepares students better for the studies ahead, and they are also emotionally more mature*" [Lec-1], and "*The additional year of study helps students to get into a self-study mode.*" [Lec-4].

Theme 2: Negative aspects of the BSc-IT ECP.

Some of the lecturers indicated that there were no negative aspects to the ECP, while others reported the following as possible negative aspects:

a) *Too much assistance*

One of the lecturers said that "*I think some students take advantage of the programme to not study hard enough because they know that the lecturer is there to assist most of the time.*" [Lec-5].

b) *Boredom*

Students with a Mathematics mark below the requirement of the standard programme need to enrol for the ECP, regardless whether the student completed IT as a school subject which already include programming skills. One of the lecturers mentioned this as a possible negative aspect as these students are bored with the content of the programming modules offered as part of the ECP [Lec-4].

Theme 3: Most important success factors.
The following sub-themes were identified to contribute towards the success of the BSc-IT ECP:

a) *Focus on fundamental concepts*

Lecturers all regard the focus on core concepts as one of the most important aspects of the BSc-IT ECP. The solid foundation on basic knowledge and skills contributes towards enabling students to have a better understanding of the work and therefore to adapt to the standard BSc-IT programme with ease.

b) *Small number of students*

The number of students that are enrolled for the ECP at the North-West University is limited to not more than 50. It was mentioned that the small number is part of the success factor. Responses included *"Students get individual attention if they struggle with the work because groups are small."* [Lec-3].

c) *Student commitment*

One of the lecturers mentioned "*student dedication and motivation*" [Lec-4] as a success factor, while another lecturer alluded to the "*dedication of students to want to learn.*" [Lec-1].

7. Discussion

Students' perceptions were categorized according to their initial perceptions of the programme, their perception after completion of the extended (first) year of study, challenges experienced, and the value of the BSc-IT ECP.

Initial perceptions: The majority of participants were excited about the BSc-IT ECP, as it provided them with the opportunity to study even though they were unsure about the content of the modules.
In response to students reporting anxiety on entering the ECP, management should take more time to explain the purpose and content of the programme at the time of registration. To achieve this, senior students in the BSc-IT programme can be involved in the orientation of first-year students to ensure that they are well-informed of what the programme entails.

Perceptions after completion of the extended (first) year of study: Almost all the participants indicated that they enjoyed the work once they engaged with it. Most participants thought that the fundamental concepts of programming were addressed well, which allowed them to gain confidence in their ability to do programming. To this effect, the BSc-IT ECP serves its purpose in providing an introductory programme to core concepts which students who enter the programme is lacking (Garraway & Lange, 2020; Sibiya & Mahlanze, 2018). The positive attitude of students towards the programme correlates with the finding of a study on the ECP at the Department of Nursing at a South African University of Technology (Sibiya & Mahlanze, 2018). They report that students initially displayed a negative attitude towards being enrolled for the ECP, but gradual improvement in their academic performance shifted their mindset towards being positive about the programme. Similarly, Bass (2007) reports that students in the field of dental technology acknowledged the positive impact that the ECP had on their confidence and performance, to the extent of being surprised at how much they benefited from the ECP at entering the main-stream programme, while Steenkamp and Anghel (2019) report that students in an ECP in the field of engineering indicated that they were better prepared in terms of mainstream knowledge than students who did not attend the ECP.

Challenges experienced: One of the challenges that was mentioned was that learning how to program is difficult. Another challenge was the lack of confidence to ask questions. Students can become negative and demotivated with a lack of academic progression (Hans, 2014). Therefore, lecturers should employ activities and provide support in an effort to ensure that students do not fall behind due to the fact that they lack the courage to ask questions. Hans (2014) advises that lecturers presenting ECP modules must be approachable. Time management was also mentioned as challenging. According to Prinsloo (2019), support in terms of time management skills should be provided by the institution since it is an important "*study skill*" that often determines the level of academic performance of students.

Valuable aspects of programme: Most participants shared the opinion that all the modules in the BSc-IT ECP are valuable. Lecturing style was also mentioned as a valuable aspect since the pace of work is slow and explanations are often repeated with many activities to implement skills. Lecturers with the skills and expertise in the subject matter should present modules in an ECP, as inexperienced lecturers cannot render the service required to assist students who need extensive support (Hans, 2014). Most of the participants express appreciation for the time and effort of lecturers who present ECP modules. The participants indicated that they adapted well to the standard BSc-IT programme, due to the fact that lecturers nurture students more in the BSc-IT ECP and take time to explain concepts repeatedly. The valuable role that lecturers play in the success of an ECP is confirmed by literature with specific reference to patience, expertise and the ability to explain difficult concepts (Van Schalkwyk, 2008).

Lecturers' perceptions were categorized into positive aspects, negative aspects and success factors for the BSc-IT ECP.

Positive aspects: As with the students, the lecturers mentioned that students had an additional opportunity to study which they would not have access to if the BSc-IT ECP did not exist. Almost all lecturers said that the time spent on foundational knowledge is one of the key aspects that contribute to the success of the programme. This view correlates with that of the student-participants who expressed appreciation for the content of the ECP modules (Garraway & Lange, 2020; Sibiya & Mahlanze, 2018; Steenkamp & Anghel, 2019).

Negative aspects: Although the majority of lecturers could not identify any negative aspects to the ECP, a few lecturers mentioned financial implications, too much assistance and boredom as negative aspects. Therefore, assessment tasks should always include higher order cognitive skills. Students who master the work well can be given more responsibilities such as tutoring. Some lecturers indicated that they might be "spoon-feeding" students too much. To this effect some of the student participants in this study indicated that they found it difficult to adapt to the pressure that they initially experienced in the transition from the extended to the standard BSc-IT programme. Therefore lecturers of extended programme modules should include sections of self-study to encourage self-directed learning. Lecturers should allow students to attempt and explore possible solutions to problems in order for them to gain confidence in solving problems on their own.

Success factors: Lecturers felt that the leading success factors include suitable content focusing on basic knowledge and skills. This ensures that students are prepared well when entering the standard BSc-IT programme. Furthermore, it comprises suitable teaching and learning conditions which include lecturers who are experienced and patient and is willing to make an additional effort to ensure that students understand the work. Content presented at a level that is accessible to students with limited or no knowledge of programming concepts and problem-solving skills adds to favourable teaching and learning conditions. In their report on new generation ECPs, Shay et al. (2016) emphasize the importance of pedagogy in BSc programmes. Deep learning and high level of thinking skills need to be obtained with more time allowed for contextualisation and by following a "*more time-on-task*" approach (Shay et al., 2016). Another important factor voiced by lecturer participants in this study is the students' attitude and willingness to learn which contributes to a great extend to their success. Factors to consider to ensure the successful delivery of a BSc-IT ECP as revealed by this study are listed in Table 3.

Table 3: Factors towards a successful BSc-IT ECP

Success factors		References to responses		
Content:		Groups	Themes	Sub-themes
Support standard BSc-IT programme content		Students:	2	a), c)
			4	b), d)
		Lecturers:	1	b)
Address fundamental knowledge and skills		Students:	1	b)
			4	b), d)
		Lecturers:	3	a)
Teaching and learning conditions:				
ıg:	Characteristics of lecturer:			
	Dedicated	Students:	4	a)
	Approachable	Lecturers:	1	b)
	Patient		2	b)
	Experienced in subject matter		3	b)
	Experienced in good teaching practices			
	Lecturing style:			
	Adaptable pace of work	Students:	4	a)
	Thorough explanations	Lecturers:	3	c)
	Repetition of work			
	Individual attention			
Learning:	Manageable pace of work	Students:	1	c)
	Small groups	Lecturers:	3	b), c)
	Student commitment			

In summary, the two main factors that were identified in offering a successful BSc-IT ECP are: content that supports the standard or mainstream programme which is supported by literature (Garraway & Lange, 2020; Makgobole & Onwubu, 2021; Sibiya & Mahlanze, 2018; Steenkamp & Anghel, 2019), and favourable teaching and learning conditions which is confirmed by research on how ECPs are perceived by students (Bass, 2007; Shay et al., 2016; Van Schalkwyk, 2008).

8. Conclusion

In the post-Covid-19 years, ECPs will become more relevant due to major disruptions in school programmes caused by the Covid-19 pandemic. The effect the pandemic could have on the academic qualifications of potential students may result in an increased number of students who do not meet the minimum requirements to enrol for academic programmes at institutions for higher education. Offering ECPs can assist in improving the academic qualifications of students to an acceptable level to enter a standard programme. However, it is important to ensure that ECPs meet the goal of improving the students' academic qualifications considering factors that contribute towards the success of these programmes.

The findings of the study show an overall positive perception from students and lecturers on the BSc-IT ECP presented at the North-West University. Although the additional year of study has financial implications, the value of the programme lies in providing students with the opportunity to study and to obtain a solid foundation of basic knowledge and skills, ensuring them to be well-prepared to adapt to the standard BSc-IT programme. Content which support mainstream knowledge and teaching and learning conditions are equally important as students need support to adapt to the higher education environment and gain confidence to enter the standard programme. Favourable learning conditions created by ECPs entail small groups, slow pace of work and repetition of work assist in obtaining problem solving skills and progress to deep learning in STEM fields of study opposed to superficial or rote learning.

9. References

Bass, G.H. (2007). *An Investigation of the Perceptions of Learners and Staff in Respect of the Dental Technology Extended First Year Programme.* (2007). Thesis. University of KwaZulu-Natal.

Case, J., Smith, L., & Van Walbeek, C. (2014). Assessing the effectiveness of academic development programmes: A statistical analysis of graduation rates across three programmes. *South African Journal of Higher Education, 28*(2), 624-638.

Garraway, J.W. (2017). Participatory parity and epistemological access in the extended curriculum programmes. *Education as Change, 21*(2), 109-125.

Garraway, J., & Lange, J. (2020). Participatory parity in South African extended curriculum programmes. *Nancy Fraser and Participatory Parity: Reframing Social Justice in South African Higher Education*, 94.

Grayson, D. J. (2010). *ENGAGE: An extended degree program at the University of Pretoria in South Africa.* Paper presented at the Proceedings of the 2010 American Society for Engineering Education Annual Conference and Exposition.

Hans, G. N. (2014). Addressing the needs of underachieving students in an extended curriculum programme.

Hay, H., & Morals, F. (2004). Bridging programmes: gain, pain or all in vain: perspectives on higher education. *South African Journal of Higher Education, 18*(2), 59-75

Kloot, B., Case, J., & Marshall, D. (2008). A critical review of the educational philosophies underpinning Science and Engineering foundation programmes. *South African Journal of Higher Education, 22*(4), 799-816.

Makgobole M.U. & Onwubu S.C. (2021). Exploring students' experience and perception of Somatology extended curriculum programme at the Durban University of Technology. *Journal of Education*, 82, 60-77.

Prinsloo, M. (2019). *An investigation into perceived stressors as barriers to student engagement in an extended degree programme.* Stellenbosch: Stellenbosch University.

Ramma, Y., Samy, M., Gopee, A., Roberts, B., & Roberts, B. (2015). Creativity and innovation in Science and Technology–bridging the gap between secondary and tertiary levels of education. *International Journal of Educational Management, 29*(1).

Shay, S., Wolff, K. & Clarence-Fincham, J. (2016). *New Generation Extended Curriculum Programmes: Report to DHET*. Cape Town: University of Cape Town.

Sibiya, M. N., & Mahlanze, H. T. (2018). Experiences of facilitators regarding the extended curriculum programme offered at a higher education institution in the province of KwaZulu-Natal in South Africa. *Curationis, 41*(1), 1-6.

Sintema, E. J. (2020). Effect of COVID-19 on the performance of grade 12 students: Implications for STEM education. *Eurasia Journal of Mathematics, Science and Technology Education*, *16*(7).

Smith, L. C., Case, J. M., & Van Walbeek, C. (2014). Assessing the effectiveness of academic development programmes: A statistical analysis of graduation rates across three programmes. *South African Journal of Higher Education, 28*(2), 624-638.

Steenkamp, H. & Anghel, C. (2019). *Exploring student perspectives on an extended mechanical and industrial engineering program*. Paper presented at the Proceedings of the 2019 ISTE International conference on Mathematics, Science and Technology Education.

Van Schalkwyk, S.C. (2008). *Acquiring academic literacy: A case of first-year Extended degree programme students*. Thesis. Stellenbosch University.

Zhang, Y., & Wildemuth, B. M. (2009). Qualitative analysis of content. *Applications of social research methods to questions in information and library science, 308*, 319.

Definite possibility or deliberate mistake - a comparative case study of undergraduate students' academic performance in the traditional versus online pedagogy in Mauritius

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Abstract
The impact of Covid-19 in Mauritius has given a new paradigm to e-education with the interactivity based on teaching and learning between students and teachers through an online platform. This paper explores in depth the practicability and realistic nature of the Tradition and Online pedagogy of undergraduate students' academic performance in a Higher Education Institutions (HEIs) in Mauritius. A descriptive analysis was done among a sample of Undergraduate students enrolled in a Business Administration programme for 6 respective cohorts (from April 2018 till August 2021) in four modules, namel, Principles of Management, Microeconomics, Business Stats and Maths, Computer in Management and Microeconomics. Moreover, the Semester Grade Point Average (SGPA) was also taken into consideration as a variable for analysing students' performances. This research findings will contribute to the literature on undergraduate students' academic performance from Traditional to Online pedagogy. The outcome indicates that there was no significant difference in students' performance when the traditional face-to-face mode and the online policy applied. The grades remained nearly the same irrespective of the different cohorts. It is highly recommended that HEIs need to focus on more dynamic approaches like socio constructivism, heutagogy and connectivism regarding the new normal mode to ensure continuity of online pedagogy. Further research can explore students' performance in other academic programmes and also at the postgraduate level.
Keywords: Students' academic performance, Traditional pedagogy, Online mode, Covid-19, Mauritius.

1. Introduction

The Higher Education Institution (HEI) in Mauritius has had a major conjecture in its educational system due to the advent of Covid-19. A new arena of hope has buzzed on with the growing demand of Online pedagogy amongst parents, teachers, students, and academicians creating, an increasing blossoming apprehension of the "new normal" reflection as an epitome of effectiveness. The avenue of the Web-based teaching and learning has been praised continuously for its numerous advantages over the traditional, mode especially for those who are working currently or doing their studies on a slow-paced mode, to students who are still stuck in their respective countries due to the pandemic situation, through a single internet connection, through the interactive platform like Moodle, Whatsapp, Facebook and Ms Team. Nevertheless, its drawbacks could also be witnessed especially for those who do not have the necessary resources or who had problems in understanding the online classes held due to connectivity issues.

The effectiveness of the traditional mode (F2F) of education vs that of the online teaching and learning pedagogy has been compared. Using a single indicator, the Undergraduate students' academic performance Semester 1 results at a Mauritian University was compared. Thus, considering the limitations highlighted in the Mozes-Carmel and Gold (2009) study, this examination was duly conducted as a base of providing additional measures to determine whether the Undergraduate students' performance was better in a specific environment compared to the other. Moreover, the

methods, procedures, as well as the means of operational tools used in this assessment, can be expanded to future qualitative, quantitative, or even mixed methods designs for further analysis of this research paper. Furthermore, the results of this study would serve as a backbone for forthcoming meta-analytical research.

2. Literature Review

2.1 The Genealogy of The Traditional v/s the Online Pedagogy

Conventionally, the face-to-face, classroom-based teaching and learning is considered as the best form of imparting formal teaching and training, which has weakened with the prevalence of the Covid-19 pandemic. According to the UNESCO research in April 2020, in more than 188 countries, universities and schools had a massive closure, thus impacting over 91% of the overall student population worldwide (UNESCO n.d.). To sustain its educational system due to the academic institutions' closure, the traditional face to face (F2F) teaching and learning was cancelled, compelling many of them to shift to a more convenient alternative which is fully web-based.

Computer based learning has changed the pedagogical landscape systematically since a larger number of students are more prone to this new educational framework. Lundberg et al (2008), stated that "think tanks" and the increasing number of online courses worldwide have been in demand dramatically. Technological advancement has improved the comfort of many students' homes. Ramkissoon (2020) stated that the advent to online pedagogy will suffice students to attend class, learn their coursework, submit assignments, and complete online examinations. Teachers still must design their curriculum of work and maximise the academic delivery effectively, even though in digital form. As there are the basic similarities of the traditional pedagogy, the teacher must maintain control of their class while students show active listening to the lectures, take notes, and even ask their questions as a student-centered practice. Needless to mention that this abrupt shift brought along a stressful phase for numerous educators and students who were keener on the in-person pedagogy. In this context as per Salcedo (2010), students are not capable fully of determining properly the class dynamics as they can only analyse information, formulate their questions, and ask for clarifications. The performance of the student has now been considered carefully in determining whether the online education is the real plausible substitute for classroom pedagogy.

Online education is not a new phenomenon and its first correspondence relating to distance learning programmes got initiated in the mid-1800s by the University of London. Only in 1873, this non-traditional education programme got the support of "Society to Encourage Home studies" by Boston, Massachusetts. According to Hodges et al. (2020), Online learning has been stigmatised as a weaker option to sustain quality education. The new and old systems of education are questionable and how best the students could learn and professors could engage themselves fully in providing excellent delivery to sustain the continuous good performance of their audience across all formats. Bower (2001) stated that technology could never replace the traditional method and no superior relationship would be met between teacher and students, thus resulting in irresponsibility if the university could not embrace all possibilities presented through technology.

2.2 21st Century: The Revolution in Pedagogy with the Covid-19 Impact

According to Garg (2020 the emergence of the pandemic of Covid-19 has affected the educational system tremendously. There has been a growing demand of students for Online Education following the pandemic. A research done by the World Economic Forum (2016) proved that greater emphasis has been laid upon the fact that the 21st Century educational system must be one where students are able to master properly the notion of extensive skills like good problem solving or even good collaboration compared to those skills acquired by the past generations in their learning curve.

Calderon and Sindhu (2014) mention that workplace skills are more important for employers compared to only a university degree in this 21st Century Education. To what extent would online classroom be a reliable substitute from that of the traditional mode of Face to Face (F2F) is questionable. The provision of equal access to education, one which highly supports justice, equality, and inclusion for all, by ensuring the timely delivery of the content of education, and at the same time engaging the learnings fully into this new carefully planned pedagogical infrastructure with the blended or fully online system of education could be seen as being "a definite possibility".

2.3 Online Pedagogy: A Necessity or a set of Rhetorical Dissonance during the Covid 19- Era?

The efficacy of the online pedagogy can expand greatly with the evolution of technology and increased awareness. Undergraduate students' demand for online pedagogy grew day by day as they wanted to experience the flexibility, time efficiency, attractiveness and quality of the programs everywhere with a single click. (Wladis et al., 2015).

Online mode has been favoured greatly for its 7 key elements which triggered the new form of pedagogy:
(i) The ongoing demand for online education
(ii) students' positive expectation
(iii) the advantages of using digitalised means like social media, mobile phone for ease of access
(iv) due to globalisation the world of work is changing rapidly
(v) the blended form of education – hybrid modes utility with both face to face and virtual classes
(vi) how collaboratively it builds a community of knowledge
(vii) the growing use of software, multimedia and online resources availability

It has also been noted that prospective students wanted to avail quality education without having to indulge themselves in the sacrifice of work timing, family timing and even travel expenses. The freedom of communication with teachers and classmates and accessing educational materials to complete assignments or even a forum for online examination have been highly solicited by the study of Richardson and Swan (2003). To further support this evidence, Lundberg et al (2008), highlighted that the flexibility in study hours for completion of an online-based degree such as a virtual classroom with a video streaming possibility after working hours would contribute positively to better in-class performance. On top of its effectiveness, Bigelow (2009)'s studies focused on the relationship of study time as well as performance and found that both were limited. Online classes do have a lot of benefits but doubt still prevails regarding its level of expectation and whether it will live up to whatever promises are made. Hoxby (2017) discussed the sustainability aspect of online pedagogy which applies only to some selective universities. She found that there is practically no mention of the cost effectiveness or the return of investment of such online pedagogy. She denoted that students rather personally have to spend more money through the use of online education compared to the face-to-face mode. However, the assumption denoted that the online student uses any additional time provided to improve the academic grades. With the online platform, students are not only limited to coursework but can access other universities' websites or even have recourse to online journals or websites to render their knowledge better. Driscoll et al., (2012) came forward with the argument that quieter students feel more comfortable in partaking of class dialogues without any instance of being judged or recognised, which can result in increasing their average academic scores. Ramkissoon (2017) further added that due to the loopholes in such an educational system, retaining students and ensuring their full satisfaction of the courses and even their performance is highly compromised compared to the traditional mode which really showcases the performance of the students.

To further support the usage of the educational mode, Peake and Reynolds (2020) conducted a study during the pandemic situation at the University of Bordeaux for students and staff. This study

highlighted that the use of social media really benefited students through their online virtual community which enhanced communication amongst themselves. On the other hand, Hasan (2020), conducted a qualitative survey with 408 students to get a gist on the effectiveness of online teaching and learning during the lockdown and it was mentioned clearly that many educational centers in India and around the world have shifted to the online mode essentially. They are more connected via-web applications like Moodle, Zoom, WebEx, Google meet, Teams etc. to sustain their educational level.

The Government of India launched an initiative called the "Bharat Padhe Online" to encourage all the tutors to use this platform for the creation of digital educational work contents, and to share their ideas and their creativity through the educational blogs. The biggest challenge witnessed was in terms of the accessibility to these platforms.

Both the Online and Traditional pedagogy have their pros and their cons. There are more studies which compare these two modalities in achieving the specific learning outcomes are required before the decision which are well informed can be made. The question on the quality of traditional and online methods is an empirical one which needs to be tested. Terry (2007) has used several graduate students in the university to test those differences based on the review of their academic performance following the traditional mode and the face-to-face mode of teaching and learning. He found that there was no significant difference in the student's performance from those taking part in face to face and those having recourse to the hybrid mode. But it was also highlighted that students who partook in the online classes failed to do well compared to when they were on campus. Bozkurt and Sharma (2020) pointed out that the practicalities of the online teaching and learning require a lot of systematic planning and prudent formulation of its aims and objectives to create a culture of effective learning. They further added that during the Covid-19 era, only uploading educational content is not fully justifiable. What is required is focus on the learners' changing needs and their context of how learning takes place and whether the students have access to online pedagogy through the educational platform offered by the university or academic institution. It is to be noted that the pace of students differs from their educational priorities.

This study aimed at examining these two modalities regarding the undergraduate students' academic performance over a lapse of three years. To ensure the successful realization, objectives of the study, research questions and hypothesis have been investigated.

2.4 Objectives of the Study

The basic objectives of this research paper are:

(1) To understand the effectiveness of online pedagogy compared to traditional face to face pedagogy in this Covid-19 Era.

(2) To assess the level of perception of undergraduate students with regards to online pedagogy by considering their attitude and behaviour, as well as their cognisance of this new mode of teaching.

(3) To compare the performance of undergraduate students achieved through Online pedagogy with Traditional face to face mode over the last 3 years.

Besides the 3 main objectives, some additional research questions have been added to help achieve the desired objectives of the study and they are formulated as below:

RQ1: What differentiates the performance of undergraduate students between online mode and face to face mode of teaching?

RQ2: How students' behaviour, attitude and cognizance impact the academic performance achieved through adopting online and traditional face to face pedagogy?

RQ3: Are there significant differences between the performance of online and F2F students with respect to students' IQ?

3. Research Methodology

This research paper is based on secondary data collected. Both explorative and descriptive research methodology have been used. The data is collected for both online and face to face teaching and learning of Undergraduate students of the faculty of Management – specifically the Bachelor of Business Administration (BBA) programme, based on 4 modules which they did in Semester One to analyse their academic performance. The results scored by 15 students per cohorts were compared each semester over a period of three years (from 2018 till 2021) as shown below.

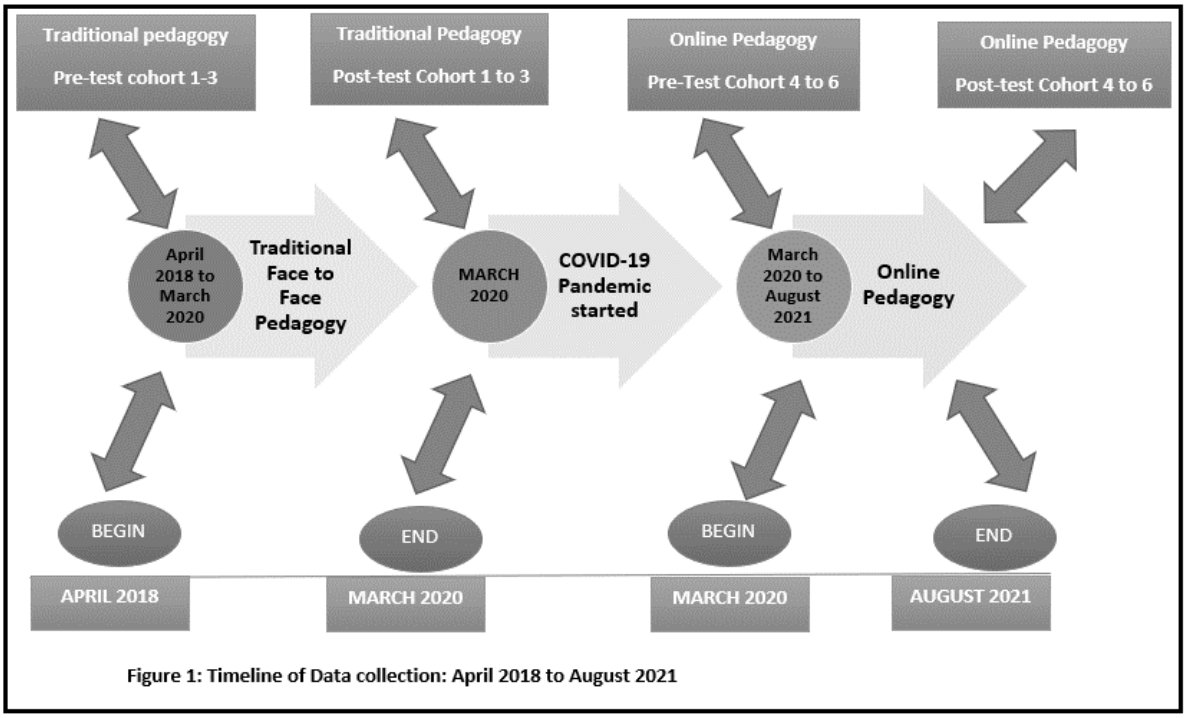

Figure 1: Timeline of Data collection: April 2018 to August 2021

4. Data Collection Procedures

The sample of 90 students' grades in total were obtained from the Examination Unit of the Institution and the grades were released to the researcher upon the approval of the Vice Chancellor, with the condition that the researcher would maintain full confidentiality. The blind grading process used in this research paper is of paramount importance as the gradings of the exam papers is subjective, and in research, subjectivity equates to biasness, in case the grader knows the identity of the student in any way. After collecting the data, the researcher analysed and processed all the data through the Statistical Package for Social Sciences (SPSS) V.22.0, to calculate all specific values required. Then the values were used to finalise the conclusion and validate the hypothesis.

Table 1: Study Sample

Format	BBA Semester 1 Courses			
	Course 1: Principles of Management	Course 2: Business Stats and Maths	Course 3: Computers in Management	Course 4: Microeconomics
Traditional Face to Face Mode	N = 15 (Students) Taught by 1 Lecturer	N = 15 (Students) Taught by 1 Lecturer	N = 15 (Students) Taught by 1 Lecturer	N = 15 (Students) Taught by 1 Lecturer
Online Mode	N = 15 Taught by 1 Lecturer	N = 15 (Students) Taught by 1 Lecturer	N = 15 (Students) Taught by 1 Lecturer	N = 15 (Students) Taught by 1 Lecturer
***Students → mixed Gender and Both National and International Students	Total Number of Cohorts: 6	Sample size: 90 Students	Total results compared: 360	

5. Test Instruments

In this research paper, the students' performance was operationalised by their final modules gradings, i.e., the SGPA. The modules' grades were derived from class test, research project assignments, quiz, in-class debates, role play and end of semester examinations. These a-forementioned assessments were fully valid and relevant, and they all were effective in gauging all the undergraduates' students' ability and performance objectives' measurements were generated. Each module was assessed on a score of 100 marks and the BBA students' performance was analysed. To test the hypotheses, correlational statistical tests and predictive tests were used.

6. Results

The research investigated has helped to answer the 3 initial research questions which were raised and to test each of the hypotheses.

Research Question 1

The first research question investigated if there was any significant difference of the undergraduate students' performance between the traditional F2F and online mode learners. To better analyze the results and performance of the undergraduates' students for the 4 modules completed in semester 1 from April 2018 till August 2021, the mean value was considered as illustrated in Table 2 for the 6 cohorts.

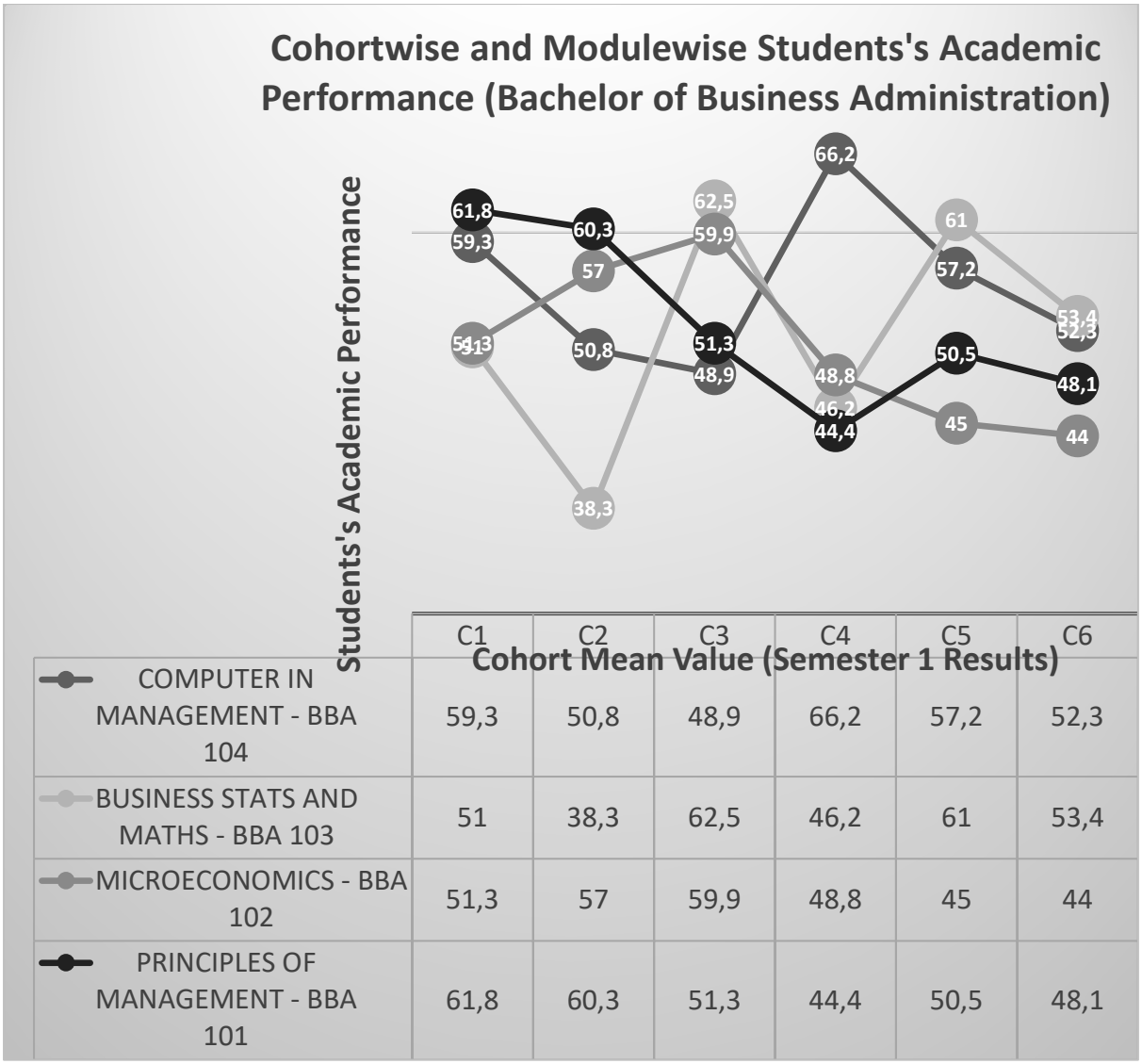

Table 2: Students' Academic Performance April 2018 to August 2021

Hypothesis 1 Tested Results:

H1: The overall students' academic performance is significantly different between traditional and online teaching mode. **(Rejected)**

The research showed no significant difference between the academic results and performance of the bachelor's degree students with regard to traditional face to face (Cohort 1 to 3) and online mode of pedagogy (Cohort 4 to 6) The following hypotheses were tested:

Students mean value of each module was considered and it was noticed that the students' overall scored marks were between 48.9, being the lowest, to 66.2, being the highest marks earned in Computer in Management (BBA 104), obtaining a grade ranging from C to B. Students from Cohort 4 to 6, benefited from achieving better marks compared to the students' who took the traditional mode pedagogy.

Research Question 2

Secondarily, the question addressed how the students' behaviour, attitude and cognizance impacted on the academic performance adopted face to face and online.

Hypotheses 2 Tested Result:
H2: The students' academic performance is different for practical and theoretical modules taught through traditional and online teaching mode. **(Accepted)**

The students' academic performance is different for practical and theoretical modules taught through traditional and online teaching mode and this has been proved by the markings obtained. Modules like Business Maths and Stats (BBA 103), Principles of Management (BBA 101) and Microeconomics (BBA 102) results were poor compared to the practical module of Computer in Management (BBA 104). It can also be analysed that the students' academic performance is different for Mathematical and Conceptual modules taught through traditional and online teaching mode.

Hypothesis 3 Tested Result:
H3: The students' academic performance while learning through online teaching mode is impacted positively by individual technological awareness. **(Accepted)**

The students' academic performance while learning through online teaching mode is impacted positively by individual technological awareness. Once again this has been proved with the appreciation and markings of students' results for the module Computer in Management (BBA 104). This further adds on to the results of hypothesis 3 where it could be analysed that the students' academic performance while learning through online teaching mode is positively impacted positively by individual technological awareness.

Hypothesis 4 Tested Result:
H4: The students' academic performance is different for Mathematical and Conceptual modules taught through traditional and online teaching mode. **(Accepted)**

From the module Business Stats and Maths (BBA 103), students' performance still resulted in being very weak and there were also huge failures in this module in the cohort 2 batch. The grading ranged between a U and B-. The students performed academically without much of a difference.
In the module Microeconomics (BBA 102), students doing the online mode did not score good results and the cohort 4 to 6 scored poor marks of C and D. The performance of students doing traditional face to face mode for the module Principles of Management (BBA 101), was better for Cohort 1 to 3 compared to that of online batches, where the students got an average of C-.

Research Question 3
The third research question helped in identifying the significant differences between the performance of online and Face to face students with respect to their IQ.
The graph below considered the mean value and showed that the students' academic performance from April 2018 till August 2021, remained the same with regard to their SGPA being 6.3. The traditional face to face mode and the online teaching mode's result were nearly the same and their IQ was not much affected. The grades obtained were still between the range of C- to B- in the 4 modules learnt.

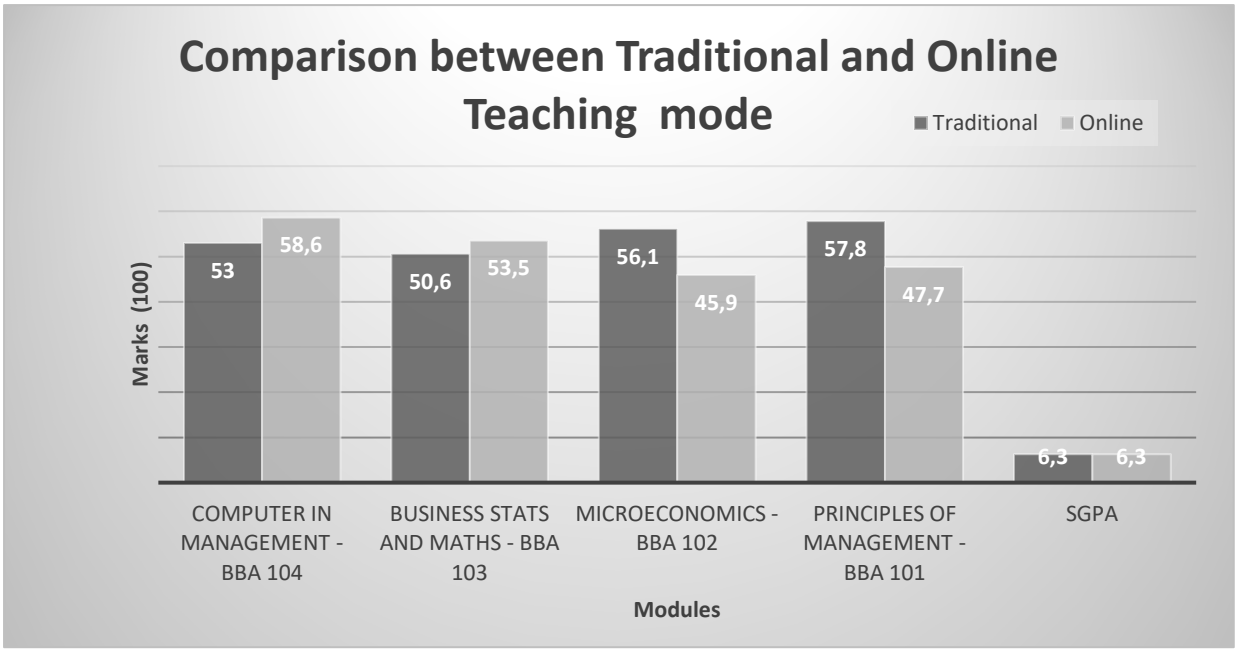

Figure 3: Comparison between Traditional and Online Teaching Mode

7. Discussion and Social Implication

The results of this research paper demonstrated that there existed no major significant difference between traditional face to face pedagogy and online pedagogy from the BBA undergraduate students after having analysed the results of 6 cohorts in 4 different modules: mainly Computer in Management (BBA 104), Business Stats and Maths (BBA 103), Microeconomics (BBA 102) and Principles of Management (BBA 101), and from April 2018 till August 2021. This result obtained was analyzed to see whether the impact of COVID-19 in Mauritius created any specific change in the results of the students once the mode of teaching and learning changed to fully online . According to Allen and Seaman (2013), the evidence has shown that the proportion of online classes tripled and students who did mostly online classes had better performance compared to the traditional face to face mode. Despite the constraints witnessed with regard to sample size issues and study limitations, the assessment of both traditional mode and online pedagogy showed that students shared the same performance when SGPA is compared.

Referring to the literature review where Lundberg et al (2008) stated that online pedagogy and its tool would improve the life of students, the study revealed that students' IQ did not change even though many IT tools and educational platforms were present. To a certain extent, students' preference for IT related subjects like Computer in Management (BBA 104), showed academic performance better in the Online Mode. The quality of teaching and learning matters and conceptual subjects which necessitate F2F interaction proved having been compromised with the advent of online pedagogy. It was noted that the academic grades of students were not brilliant and most of them ended with lower grades like C- or B-.

This research supports the work of Gratton-Lavoie & Stanley (2009), where they found that the result of this study was synonymous to theirs in the sense that there was no significant difference in the end of the semester exams' academic results and performance of the undergraduate students for both online and traditional methods. It was also to be noted that previous research could hardly gather randomised undergraduate students into experimental groups of online and traditional face to face sections. Students who had exams online using methodology of online assessment or open book

assessment had more advantage in terms of the days of submission – 2 days compared to the traditional students who had 3 hours written paper to test their knowledge.

With reference to the IT module, gained more difference in their grading and score in the online mode, and this supported the research of Parsons-Pollard, et al. (2008) where the level of achievement was slightly higher. It can be denoted that the retention and graduation rate could be increased by the traditional face to face mode. This also was aligned to the Bernard et al (2009) research where they did a meta-analysis of 3 types of interaction in distance learning education. It was found that there was a strong association between the modules which were IT related and when merged to distance learning courses. The researchers Larson and Sung (2009) further pointed out that this was due mainly to cognitive engagement causing a higher rate of achievement.

There was a high level of absenteeism for online classes in the quest to cut cost by the academic institution and because the pandemic situation has forced it to be like this. Therefore, the aim of maximizing learning was compromised on online delivery. Students' and lecturers' preparation for online classes were also hindered by the advertence of covid 19 which forced the shift to the online mode abruptly. Face to face courses is usually preferred by students when courses take place during office hour times (8:30 am to 4 pm).

In this research paper, 4 hypotheses were compared between the online mode and Traditional Face to face mode. The null hypothesis was rejected. At the level of academic performance and gradings, the finding showed that traditional face to face delivery and online delivery somehow achieved the same results. According to Zhang and Worthington (2017), it was reported that there was an increasing cost benefit for the use of online education compared to the traditional one. The use of online pedagogy was also acclaimed by 37 Australian universities which proved their outcome to be successful over a lapse of 9 years (from 2003 to 2012).

The social implication of the study should be focused upon, especially taking into consideration the "Grading or results achieved" by the undergraduate students in semester 1 modules to determine the depth of their performance which was lacking. It can be clearly explained abruptly that marks or grades obtained in class during an assessment period might not really reflect the real ability and potential of students if there was any group assessment conducted. Clear performance indicators (KPIs) should be highlighted which are both qualitative and quantitative in nature and where their measurement is plausible.

The second consideration would be the student's sample. Each cohort has a varied number of students and therefore only 15 students per cohort were analysed. Moreover, future studies revealed that more emphasis should be laid upon the timing of online courses versus the traditional face to face mode. The student's sample selection should in the future be dissected from local (Mauritian) to international (foreign) students as performance, skills and aptitude could vary as well. Following the similar significance of traditional and online pedagogy in terms of students' academic performance, future research should be conducted to eliminate all spurious causal relationships and thus further add on generalisability.

Thirdly, in this research paper, it could be seen that the students' knowledge for modules like Computer in Management was more favourable compared to the modules which required practical sessions like Microeconomics (BBA 102) or Business Stats and Maths (BBA 103).

Lastly, future research should consider the "teaching ways" of both online and traditional classes. The quality of teaching must be an important factor in developing relevant educational strategies to help foster the culture of learning amongst the students. Lecturer's ability to teach online should also be

evaluated and proper training should be given to them to ensure quality standards as prescribed by the “bloom taxonomy”. The absence of hands-on in class exercises and the lack of self-discipline of students should also be of concern to the online faculties. As mentioned by Garg (2020), it is futile to start online teaching and learning on a hurried and unplanned way as its practicalities are often very much questioned. So many challenges could be outlined.

8. Recommendation

1	To have a blend of Hybrid pedagogy instead of shifting totally to online pedagogy after the pandemic is over.
2	To put in place a quality assurance monitoring system which caters for the effective teaching and learning pedagogy to sustain engagement.
3	To implement a good policy for online assessment and examination which students can take good cognizance of; but it is important to do a pilot test to ensure it’s effectiveness.
4	To set proper KPIs to academicians on how to improve the online teaching learning which would contribute to having students performing better.
5	To do a survey to evaluate the possibilities of students’ accessibility to resources like internet, Moodle, social media, and MS team, where lectures are usually being conducted.
6	To also promote the notion of online pedagogy and its essence to academicians so that they can give their best in the delivery of the students’ modules to improve their performance.
7	To implement a student centric E-Resources where students can have online access quickly even through mobile phones.
8	Training of both students and teachers on how to use the online tools.

9. Conclusion

The impact of Covid-19 in the Mauritian Higher Education Institutions (HEIs) has been reoriented towards one which would give learners the synergistic and complementary instruction despite the challenges met. There should be no quick fix solutions but rather one which fits all concept. To ensure

the effectiveness of implementing the online mode of pedagogy, the readiness of the academic institutions is important. Learners' abilities vary, and therefore, the educational context should be customised accordingly, based on their pace of learning to create a good learning culture. Mauritius is still a developing country and in terms of technology advancement for quality education it is still lagging behind.

The study performed at an academic institution in Mauritius revealed that the undergraduate students' academic performance of Semester 1 from April 2018 till August 2021 for online pedagogy or traditional face to face one, remained unchanged. If proper planning is done, there would be no questions raised about the effectiveness of both methods. In-depth research must be continued to create a good roadmap to implement new policies and capacity building with regard to how it should be done and, thus, a sense of harmony would prevail from both lecturers and learners' side in future. The provision of equal access to education, one which highly supports justice, equality, and inclusion for all, by ensuring the timely delivery of the content of education, and at the same time engaging the learnings fully into this new carefully planned pedagogical infrastructure with the blended or fully online system of education could be seen as being "a definite possibility".

10. Limitations of the Study

The limitations of the research paper centered around the nature of the sample cohorts, undergraduate students' skills and abilities, and students' familiarity with online pedagogy which impacted on their academic performance. The study focused essentially on the secondary data provided by the examination unit of the university. The students' perception about online pedagogy vs the traditional one was not compared. The study limits one to only academic semester one over the lapse of three years from 2018 till 2021. Due to the limitation in the application of the online mode, which resulted only after the first pandemic situation started in March 2020, no further analysis could be done for the overall students' modules. In addition to only comparing the efficacy of the Online and Traditional pedagogy, future research should also focus on the effectiveness of the blended or hybrid mode.

11. Data Availability Statement

The datasets generated for this research paper are available upon request to the corresponding author.

12. Ethical Consideration

The research paper involves human participants and figures were reviewed and approved by the chosen University. Written consent informing about the participation and affiliation with the said university was not required for this study as confidentiality was maintained by both parties, respecting the Data Protection Act of Mauritius simultaneously.

Conflict of Interest

The authors declare that they have no competing interests while doing this research paper.

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13. References

Affouneh, S., Salha, S., N., Khlaif, Z. (2020). Designing quality e-learning environments for emergency remote teaching in coronavirus crisis. Interdisciplinary Journal of Virtual Learning in Medical Sciences, 11(2), 1–3.

Agasisti, T., and Johnes, G. (2015). Efficiency, costs, rankings and heterogeneity: the case of US higher education. Stud. High. Educ. 40, 60–82. doi: 10.1080/03075079.2013.818644

Allen, I. E., & Seaman, J. (2013). Changing course: Ten years of tracking online education in the United States. Babson Survey Research Group. Pearson Publishers and Sloan Foundation.

Appavoo P, Sohoraye M, Gungea M, Armoogum V (2016). 'Webagogy' - the next milestone after pedagogy and andragogy?. 2016 IEEE International Conference on Emerging Technologies and Innovative Business Practices for the Transformation of Societies (EmergiTech)

Affouneh, S., Salha, S., N., Khlaif, Z. (2020). Designing quality e-learning environments for emergency remote teaching in coronavirus crisis. Interdisciplinary Journal of Virtual Learning in Medical Sciences, 11(2), 1–3.

Barboni, L. (2019). From shifting earth to shifting paradigms: How webex helped our university overcome an earthquake. *CISCO, Upshot By Influitive*.

Basilaia, G. , Dgebuadze, M., Kantaria, M., & Chokhonelidze, G. (2020). Replacing the classic learning form at universities as an immediate response to the COVID-19 virus infection in Georgia. *International Journal for Research in Applied Science & Engineering Technology*, *8*(III).

Baytiyeh, H. (2018). Online learning during post-earthquake school closures", Disaster Prevention and Management. An International Journal, 27(2), 215–227. https://doi.org/10.1108/DPM-07-2017-0173

Biel, R., and Brame, C. J. (2016). Traditional versus online biology courses: connecting course design and student learning in an online setting. J. Microbiol. Biol. Educ. 17, 417–422. doi: 10.1128/jmbe.v17i3.1157

Brianna, D., Derrian, R., Hunter, H., Kerra, B., Nancy, C. (2019). Using EdTech to enhance learning. International Journal of the Whole Child, 4(2), 57–63.

Carey, K. (2020). Is everybody ready for the big migration to online college? Actually, no. *The New YorkTimes*. https://www.nytimes.com

Craig, R. (2015). A Brief History (and Future) of Online Degrees. Forbes/Education. Available online at: https://www.forbes.com/sites/ryancraig/2015/06/23/abrief-history-and-future-of-online-degrees/#e41a4448d9a8

Daniel, J. (2020). Education and the Covid 19 Pandemic, available at: https://link.springer.com/content/ pdf/10.1007/s11125-020-09464-3.pdf (accessed 26 May 2020).

Garg, S. (2020). Artificial Intelligence and its Impact on Higher Education in Post COVID Era, University News, Association of Indian Universities, New Delhi, Vol. 58 No. 36, pp. 2-6.

Gratton-Lavoie, C., & Stanley,D. (2009). Teaching and learning principles of micro economics online: An empirical assessment. Research in Economic Education. Winter, 3-25.

Hasan, N. (2020). “Online teaching-learning during covid-19 pandemic: students’ perspective”, The Online Journal of Distance Education and e-Learning, Vol. 8 No. 4, pp. 202-2013, available at: https://www.researchgate.net/publication/344932812_ONLINE_TEACHING-LEARNING_DURING_COVID-19_PANDEMIC_STUDENTS%27_PERSPECTIVE (accessed 23 January 2021).

Huang, R. H., Liu, D. J., Tlili, A., Yang, J. F., Wang, H. H., Zhang, M., Lu, H., Gao, B., Cai, Z., Liu, M., Cheng, W., Cheng, Q., Yin, X., Zhuang, R., Berrada, K., Burgos, D., Chan, C., Chen, N. S., Cui, W., Hu, X. , et al. (2020). Handbook on facilitating flexible learning during educational disruption: The Chinese experience in maintaining undisrupted learning in COVID-19 outbreak. Smart Learning Institute of Beijing Normal University.

Herman, T., and Banister, S. (2007). Face-to-face versus online coursework: a comparison of costs and learning outcomes. Contemp. Issues Technol. Teach. Educ. 7, 318–326.

Jianey Flore, Irene Govender (2020). "Factors Influencing Secondary School Teachers' Beliefs and Intention to Accept Online Professional Development: An Empirical Study in Mauritius," Universal Journal of Educational Research, Vol. 9, No. 4, pp. 880 - 890, 2021. DOI: 10.13189/ujer.2021.090422.

Kebritchi, M., Lipschuetz, A., Santiague, L. (2017). Issues and challenges for teaching successful online courses in higher education. Journal of Educational Technology Systems, 46(1), 4–29

Kemp, N., and Grieve, R. (2014). Face-to-Face or face-to-screen? Undergraduates’ opinions and test performance in classroom vs. online learning. Front. Psychol. 5:1278. doi: 10.3389/fpsyg.2014.01278

Littlefield, J. (2018). *The difference between synchronous and asynchronous distance learning*. https://www.thoughtco.com/synchronous-distance-learning-asynchronous-distance-learning-1097959

Liu, Y. (2005). Effects of online instruction vs. traditional instruction on student’s learning. Int. J. Instruct. Technol. Dist. Learn. 2, 57–64.

Lorenzo-Alvarez, R., Rudolphi-Solero, T., Ruiz-Gomez, M. J., and Sendra-Portero, F. (2019). Medical student education for abdominal radiographs in a 3D virtual classroom versus traditional classroom: a randomized controlled trial. Am. J. Roentgenol. 213, 644–650. doi: 10.2214/AJR.19.21131

Martin, A. (2020). *How to optimize online learning in the age of coronavirus (COVID-19): A 5-point guide for educators*.
https://www.researchgate.net/publication/339944395_How_to_Optimize_Online_Learning_in_the_Age_of_Coronavirus_COVID-19_A_5-Point_Guide_for_Educators

Mozes-Carmel, A., and Gold, S. S. (2009). A comparison of online vs proctored final exams in online classes. Imanagers J. Educ. Technol. 6, 76–81. doi: 10.26634/jet.6.1.212

Mann, J. T., and Henneberry, S. R. (2014). Online versus face-to-face: students’ preferences for college course attributes. J. Agric. Appl. Econ. 46, 1–19. doi: 10.1017/S1074070800000602.

Partlow, K. M., Gibbs, W. J. (2003). Indicators of constructivist principles in internet-based courses. Journal of Computing in Higher Education, 14(2), 68–97.

Parkes, M., Stein, S., Reading, C. (2014). Student preparedness for university e-learning environments. The Internet and Higher Education, 25, 1–10. https://doi.org/10.1016/j.iheduc.2014.10.002

Parsons-Pollard, N., Lacks, T.R., & Grant, P.H. (2008). A comparative assessment of student learning outcomes in large online and traditional campus-based introduction to criminal justice courses. Criminal Justice Studies, 2, 225-239

Ramkissoon, S.D. (2017) 'A pedagogically-informed model of Massive Open Online Courses (MOOCS) for Mauritian higher education'. PhD thesis. University of Bedfordshire.

Ramkissoon, Parmeswar; Belle, Louis Jinot; Bhurosy, Trishnee (2020). *International Journal of Evaluation and Research in Education*, v9 n4 p833-839

Richardson, J. C., and Swan, K. (2003). Examining social presence in online courses in relation to student's perceived learning and satisfaction. J. Asynchr. Learn. 7, 68–88.

Santally, M.I., Govinda, M. & Senteni, A. (2005). The University of Mauritius e-Learning Model: Practice, Pedagogies and Tools. In P. Kommers & G. Richards (Eds.), *Proceedings of ED-MEDIA 2005--World Conference on Educational Multimedia, Hypermedia & Telecommunications* (pp. 619-625). Montreal, Canada: Association for the Advancement of Computing in Education (AACE). Retrieved September 28, 2021 from https://www.learntechlib.org/primary/p/20150/.

Saxena, K. (2020). *Coronavirus accelerates pace of digital education in India*. EDII Institutional Repository.

Shivangi Dhawan (2020). Online Learning: A Panacea in the Time of COVID-19 Crisis. Journal of Educational Technology Systems. doi/10.1177/0047239520934018.

Singh, V., Thurman, A. (2019). How many ways can we define online learning? A systematic literature review of definitions of online learning (1988-2018). American Journal of Distance Education, 33(4), 289–306.

Stack, Steven Dr. (2015) "Learning Outcomes in an online vs traditional course," International Journal for the Scholarship of Teaching and Learning: Vol. 9: No. 1, Article 5. Available at: https://doi.org/10.20429/ijsotl.2015.090105

Stern, B.S. (2004). A comparison of online and face-to-face instruction in an undergraduate foundations of American education course. Contemporary Issues in Technology and Teacher Education, 4(2), 196-213.

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Tull, S. P. C., Dabner, N., Ayebi-Arthur, K. (2017). Social media and e-learning in response to seismic events: Resilient practices. Journal of Open, Flexible and Distance Learning, 21(1), 63–76.

Zhang, L.-C., and Worthington, A. C. (2017). Scale and scope economies of distance education in Australian universities. Stud. High. Educ. 42, 1785–1799. doi: 10.1080/03075079.2015.1126817

What are the Advantages and Disadvantages of using wiki in Mathematics Teaching and Learning?

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Abstract
The popularity of social media in the past few decades and the COVID19 pandemic have motivated many researchers to utilise social media tools, services and applications for educational activities in higher education. Wikis are amongst the media tools being used in teacher education. However, few empirical studies have investigated wikis in mathematics education. The current study investigated the advantages and disadvantages of using wiki in mathematics teaching and learning from the perspective of pre-service teachers. The methodology used is a quantitative approach in the form of a survey which was conducted amongst seven mathematics pre-service teachers who were given a group assignment that was done on a wiki page. In this survey, pre-service teachers had to reflect particularly on that assignment. Thematic analysis is used to single out commonalities and differences. The findings illustrate that there are advantages and disadvantages of using wikis in mathematics teaching and learning. Amongst the advantages posited by pre-service teachers were that wikis enhance reading and writing skills and allow them to collaborate and share ideas. The disadvantages that the pre-service teachers mentioned were that some of the students are not familiar with wikis and those who are familiar, used wikis casually only and not in mathematics teaching and learning, and that wikis are not used outside Blackboard. The results can provide guidance to mathematics education lecturers and mathematics pre-service teachers who wish to embark on using wikis in education more especially in mathematics.
Keywords: wiki, mathematics education, advantages, disadvantages.

1. Introduction

Although wikis are used generally to provide a collaborative learning environment in education (Martin & Premadasa, 2010), it is however rare to find examples where pre-service students explore wikis in their mathematics education course in the South African context. With wikis being used widely to distribute knowledge outside of academia, some educators have suggested that wikis and their collaborative features might also be used in academic settings to support collaborative learning (Zheng, Niiya & Warschauer, 2015). Hence, the purpose of this study is to explore the advantages and disadvantages of using wikis in mathematics teaching and learning from the perspective of the pre-service teachers.

Wikis are defined as simple to use asynchronous, web based collaborative hypertext authorising systems (Desiles, Raquest & Vinson, 2005). They are web pages that people can edit directly, update, modify or delete, and refine content iteratively (Vossen & Hagemann,2007; Krebs, Ludwig & Muller, 2010). Additionally, Mirk, Burkrewics and Komperda (2010), and Guth (2007) argue that when students are using wikis, they are able to create collaborative knowledge spaces that harbour learning practices that extend beyond the boundaries of traditional formal education, allowing multiple users from different locations to collaborate in real-time (Mirk, Burkrewics & Komperda, 2010; Guth,2007; Bingimlas, 2017). Specifically, this study aimed to give answers to the question: What are the advantages and disadvantages of using wikis in mathematics education? The results of the current study may assist other mathematics lecturers in Higher Education Institutions, and pre-service mathematics teachers in using wikis in their mathematics teaching and learning.

2. Literature Review and Model Development

To guide the researcher's investigation and develop a discussion, the researcher drew from a previous review and identified a question. The researcher found Collaborative Learning by Rutherford (2014) a framework suitable for this study as wikis are all about collaborations and sharing of ideas. This theory helps us to understand the advantages of using wikis in mathematics teaching and learning as wikis are a form of collaborative …. (Donnely & Boniface, 2013).

2.1 Advantages of using wikis in Mathematics Teaching and Learning

Despite the vast investments in technology resources for schools and universities, the realities of schooling and the complexities of technology–equipped environments resulted in a much slower integration process than was predicted in the 1980s (Lavicza, 2010). This much slower integration process is due to the promise of the rapid expansion of technology use in education that has not been realised (Becker, 2001; Cuban, Kirkpatrick, & Peck, 2001; Ruthven, 2008). Additionally, technology still plays a marginal role in mathematics teaching and learning (Becker, 2001; Cuban, Kirkpatrick, & Peck, 2001; Ruthven, 2008). From this view, one can argue that in spite of the recognised importance of technology use in mathematics education, the initial enthusiasm for its potentials seemed to have weakened during the past few years (Laborde, 2008). However, there are advantages of using wikis in mathematics education.

According to Krebs, Ludwig, and Muller (2010), using wikis encourages students to generate their own knowledge in practice and provide them with the responsibility for their own active learning. Active learning means that content is created in cooperative learning settings. Wikis encourage students to read the material and reading the material enhances the understanding of the literacy nature of language (Alm, 2006). Furthermore, when students use wikis they become part of an active learning community (Alm, 2006), and thus change the individual focus of a traditional instrument to one of collaboration and shared construction of knowledge (Mejias, 2006). Thus, it is very interesting to know that wikis are not limited to teaching and learning, they can be used for class management tasks also such as distributing information, materials and communications with students (Zorko, 2009).

Studies (Krebs, Ludwig, & Muller, 2010; Mirzajani, Alizadeh, Gorji, Zerafat, Saravi & Alami, 2015) suggested a few examples where wikis can be used in mathematics: Students can use wikis when generating content and mathematical quizzes in calculus to share and present the outcome of an optimisation problem that requires small groups. There are also mathematics related wikis that provide pages and links that describe many different branches of mathematics that can be used. In fact, wikis have the ability to retrieve the content of the older versions and can record the edited content (Mirzajani et al, 2015). However, the most common use of wikis is being used as a portal for distributing and collecting mathematics course material (Mirzajani et al., 2015). Thus, there are issues to be considered by teacher-educators and students when using wikis.

According to Zorko (2009), teacher-educators should select a user-friendly wiki interface that can be navigated easily and conduct a practice task before starting the real project (Cole, 2009; Zorko, 2009). Furthermore, teachers are encouraged to create well-designed activities that require collaboration (Larussen & Alterman, 2009) and instruct students how to assess peer contributions (Cole,2009). When teachers instruct students they should include a set of rules as some students can delete others work unintentionally and that can cause problems amongst students (Cole,2009). Furthermore, teachers need to be aware that by requiring posting of homework, students make public their work to the entire internet, unless access restrictions to the course wiki are set so that only students can get into it (Ben-Zvi, 2007) which is something universities offer as they are using blackboard.

3. Disadvantages of Using WiKis in Mathematics Teaching and Learning

Notwithstanding the advantages of using wikis in mathematics, there are disadvantages of using wikis. Wikis are about working collaboratively, not individually. However, Krebs, Ludwig and Muller (2010) argue that some students would divide the work into different parts and work rather independently on their individual tasks and that is not collaboration. Working independently is argued by Krebs, Ludwig and Muller (2010) as rather cooperative. Cooperative learning is a more teacher-centred way to facilitate the cognitive and effective benefits that student-student interaction offers, whereas collaborative learning is more student centred (Jacobs, 2015).

Transformation can be quite challenging at times, resulting in teachers and students becoming reluctant or being afraid to use technology (Martin & Premadasa, 2020; Tachie, 2019). The reason for being reluctant and afraid of using technology could be the lack of examples where students contribute significantly to course-based wikis in mathematics (Martin & Premadasa, 2020) and not getting used to technology as students use wikis rather on an irregular basis (Krebs, Ludwig, & Muller, 2010). Furthermore, teachers often fail to address opportunities regarding the usage to address this situation (Tachie, 2019). As much as teachers are reluctant to use technology, the implementation of technology in education is placed on teachers and students as they are expected to adapt to those changes and learn how to best use technology for teaching, learning and communication (Ben-Zvi, 2007). Thus, teachers need to address opportunities regarding the usage of technology and change the situation as the use of technology is becoming an essential tool in mathematics (Tachie, 2019).

Additionally, to the disadvantages discussed above is time. Using wikis can be too time consuming if not used properly, and students are not prepared enough for the journey of using wikis (Krebs, Ludwig and Muller,2010). Using wikis is time consuming due to the fact that teachers are required to conduct a practice task before starting the real project (Cole, 2009; Zorko, 2009) and are expected to be patient with students as some of the students do not use wikis on a regular basis. Similar to the advantages of using wikis, there are disadvantage issues that should be considered by teachers when using wikis.

When syllabus designers are considering integrating wiki-based learning into a course, they should ensure that the course objectives are aligned with the students' abilities (Mirzajani *et al*.,2015). Furthermore, there is usually no need to incur any additional infrastructure costs as universities' campuses are already wired for internet connectivity (Ben-Zvi,2007); the challenge would be when they go out for teaching practice as some of the schools do not have internet and wikis need Blackboard. However, using collaborates can help even those with no access to the internet as students with access will be able to share the information with students with no access to internet. From the views above, one can argue that the advantages of using wikis in mathematics teaching and learning outweighs the disadvantages (Tachie, 2019).

4. Methodology

The study employed quantitative methods which allowed the researcher to evaluate pre-service students' opinions regarding the use of wikis, thereby facilitating comparisons (Yilmaz, 2013). The rationale of the study was to identify the advantages and disadvantages of using wikis in mathematics teaching and learning with the purpose of guiding mathematics lecturers who wish to use wikis in their teaching. The questions asked were not straight to the point questions, participants were not asked to list the advantages and disadvantages but questions were simplified and broken down into different components that were linked to the advantages and disadvantages. They were then classified according to advantages and disadvantages.

Cluster sampling was used to select participants as the number of participants was small and fixed and they all participated (Brown & Manly, 1998). The data were collected from seven Mathematics Post Graduate Certificate in Education (PGCE) pre-service teachers. Seven pre - service teachers were the last group of students, due to the phasing out of the old programme, thus everyone participated.

Students were grouped into two groups for the assignment, not for the study. Each group had its own topic and a leader. One group consisted of three members (two males and one female) and the other group consisted of four members (one male and three females). The selection was not based on gender. 10 pieces of papers with letters A or B were used and students were asked to pick one piece of paper with letter A or B. Three picked A and four students picked B and that is how they were grouped. However, for the study, pre-service teachers were working individually, not in groups, reflecting on the assignment that was given to them. Each student had to log in with their own account in order to create and edit wiki-pages.

In that assignment, pre-service students were asked to design a wiki page on the topics provided to each group. All members were expected to make changes, add information and pictures and edit until they came up with the final set of rules. It was not the first time they used wikis in the mathematics classroom as they had started with a practice session on how to use wikis before starting their project. That was done immediately after being introduced to discussion forums. The training was for 1 hour and they were given an opportunity to practise and play around with the tools. Thereafter, they were assigned to groups.

This study was based on their reflections, where they reflected on the assignment they were given as groups. The questions asked encouraged students to write about their learning experiences, understandings, concerns and difficulties. This reflective activity was valuable to the teacher-educator – to reflect on students' (mis) understandings and attitudes as well as for other students – to relate to their peers' experiences. Students were informed that the purpose of the survey was to gain valuable feedback regarding the efficacy of the assignment they did using a wiki. They were provided with five simple questions and were requested not to write their names when answering the questions. The questions asked were as follows:

(a) What skills were learned from using wikis and what are the benefits of using wikis?
(b) What more would they like to learn about wikis?
(c) Can wikis be used as an alternative in mathematics teaching and learning?
(d) Have they ever used wikis before more especially in Mathematics Teaching and Learning?
(e) What things would they like to change or add if given a chance to use them again?

Some of the questions were to examine the advantages of using the wikis, some were to examine disadvantages of using wikis and recommendations for future use. When analysing the data, thematic analysis was used where common and different themes were identified from their responses. The responses were classified according to the advantages or disadvantages of using wikis.

5. Results and Discussions

This study aimed to explore the advantages and disadvantages of using wikis in mathematics teaching and learning from the perspective of the preservice teachers. The results are presented and discussed according to the survey questions.

5.1 What skills were learned from using wikis and what are the benefits of using wikis?

The findings show that: students learned how to edit post live, how to incorporate various online activities into one platform, how to collaborate with other students, synchronous communication, , their computer skills were enhanced, there was no need for physical contact, there was flexibility of using wikis as they can use wikis anytime and share ideas remotely, researching online and discussing ideas with others in a professional manner, no one was limited as everyone was free to share information as much as they can, they were able to express themselves freely, collect information from other students, integrating ideas, and critiquing and sharing resources. Additionally, the findings

revealed that the use of wikis enhanced their writing and reading skills, which is something that helps mathematics students to consolidate their thinking**.**

5.2 What more would they like to learn about wikis?

Pre - service teachers wished to know how to undo the work that had been edited a long time ago, how to use wikis outside Blackboard as they require a learning management system, how to give feedback to the lecturer, and how to become a leader and be able to generate, control and hold a discussion?

5.3 Have they ever used wikis before more especially in Mathematics Teaching and Learning?

The students said 'yes' 'no' and 'not yet'. The figure below shows the percentage of students who gave these answers.

Figure 1: *Wikis as an alternative in Mathematics Teaching*

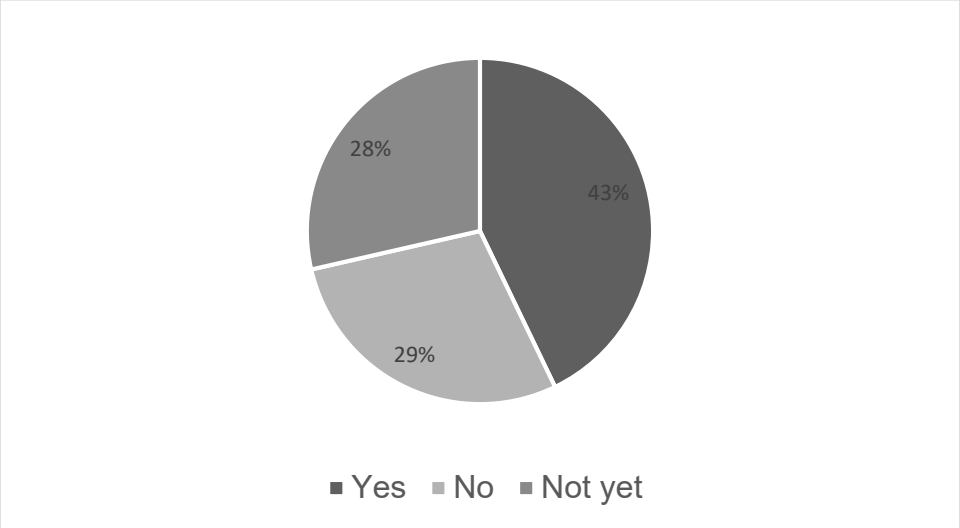

Figure 1 above shows the number of students who said 'yes', 'no' or 'not yet'.

The figure shows that the majority said 'yes' wikis can be used as an alternative in the teaching of mathematics. Students who said 'no' highlighted a few reasons. Some of the students indicated that they cannot be used yet as they require infrastructure and mobile data bundles and data bundles are expensive. They also mentioned that mathematics needs to be done in class, and that one cannot do proper demonstrations in wiki as it does not have whiteboard for working out mathematical problems. Furthermore, wikis need Blackboard and the interaction is between the same group of learners and that it is stressful as some do not participate fully. Students who said 'yes' indicated that wikis can be good for theory discussions of mathematics in some of the topics like theorems, that mathematics information can be shared and students can collaborate.

5.4 Have they ever used wikis before more especially in Mathematics Teaching and Learning?

Figure 2: *Use of Wikis in Mathematics*

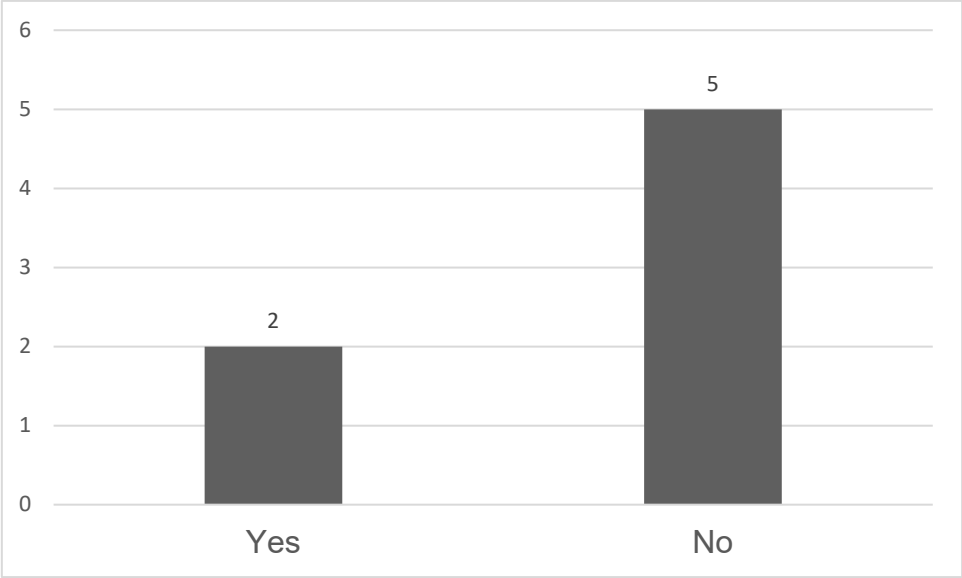

Figure 2 above shows the number of students who were familiar with wikis in mathematics and the number of students who were not familiar and never used wikis in mathematics. Out of seven students, five of them never used wikis in mathematics, and two students indicated that they did use wikis but not in mathematics.

5.5 What things would they like to change or add if given a chance to use them again?

They recommended that: wikis have a whiteboard for demonstrations, all subjects should use wiki so that students get used to it, a hyperlink be used for answering questions and that would allow wikis to be a questioning tool for assessment and not only for discussions, and use google documents as it is more user friendly.

6. Discussion

6.1 Question 1

This section examined the advantages of using wikis. Findings show that the use of wikis enhanced their writing and reading skills, were able to edit their work, and the platform was flexible as they were working from home and would work on the document at their convenient time (Cho & Huang, 2014). The findings were similar to the study conducted by Lai and Ng (2011), where they state that the editing and history features of wikis are particularly helpful for users, allowing them to trace the content. Additionally, using wikis will help pre-service teachers in their formative assessment when they start practising teaching (Lai & Ng, 2011). According to Wheeler[1] and Wheeler[2] (2009), using wikis raises students' skill levels in writing. From this view, one can say that wikis do help students enhance their writing and reading skills as well as edit their work.

6.2 Question 2 and Question 3

Most of the responses from Question 2 examined the disadvantages of using wikis and question 3 examined both advantages and disadvantages of using wikis in the mathematics teaching. Starting with the disadvantages, the participants who said 'no' argued that they cannot do proper demonstrations in wikis. Similarly, Krebs, Ludwig and Muller (2010) argued that there is a lack of mathematical tools in wikis. Moreover, findings from the study conducted by Zheng, Niiya and

Warschauer (2015) show that wiki–supported collaborative learning cannot function without an effective design which in this case is Blackboard. Thus, the learning management system will be required for teachers to use wikis in their schools.

In addition to the advantages outlined above in 6.1, the participants who said 'yes' justified their answer by saying wiki can be good for theory discussions in mathematics such as theorems. Similarly, topics such as geometry, parabola, probability and calculus were amongst the topics that were chosen for the wiki project (Krebs & Ludwig, 2009). From this view, one can argue that wikis can be of use in discussing theory concepts in mathematics including theorems.

6.4 Question 4

Findings show that the majority of students were not familiar with wikis, more especially in mathematics teaching and learning (see Figure 2) (Krebs, Ludwig & Muller, 2012). Those who were familiar with them never used them in mathematics. Thus, pre-service teachers need to be exposed to the use of wikis in their mathematics. Moreover, they need constant encouragement and support when engaging with wikis.

6.5 Question 5

Findings for this question suggest that wikis be used frequently so that students can get used to them as they do not use them frequently. Frequent use of wikis will enhance and develop teaching pedagogies of pre-service teachers. Additionally, frequent use of wikis makes learning become a collaborative process by the group and allows content creation in particular writing and refining content iteratively (Sebbowa, Ng'ambi and Brown, 2014; Krebs, Ludwig, & Muller, 2012). Furthermore, students in the assignment that was given to them were also expected to read other students' work and edit; the whole process was of emphasising academic literacy to help students see the value of writing and reading in mathematics learning (Ulleberg & Solem, 2014) and also helped students to consolidate their thinking and clarify their thoughts and ideas (NCTM, 2000). Thus, pre-service teachers should be encouraged to explore wikis in their mathematics teaching. A study focusing on the use of wiki by teachers from rural schools would be of interest for future studies.

7. Conclusion

In conclusion, this study indicates that most of the pre - service teachers were not familiar with wikis; they did not use them before and those who were familiar with wikis did not use them in mathematics, even though they are familiar with other technology tools. It is recommended that lecturers in Higher Education Institutions (HEIs) make use of the wikis so that pre - service teachers get used to using them in mathematics. Additionally, studies argued that teacher-educators should be re-trained periodically in order to have ideas of innovative approaches of teaching mathematics. By so doing, they will be enhancing writing and reading skills of students in mathematics.

The findings of this study can provide guidance to mathematics education lecturers, mathematics preservice teachers and other teachers or lecturers in general who embark or wish to embark on using Wikis in education, particularly in mathematics teaching. This study should contribute to more effective use of wikis in mathematics education in the future and the study recommends that lecturers of HEIs should relinquish at least some of their authority in traditional teaching methods, and gain some familiarity with the potential utilisation of wiki applications. With these findings, it is clear that mathematics educators should be re-trained periodically in order to have ideas of innovative approaches of teaching mathematics.

Further investigation on the use of wikis is necessary because studies of certain issues are fairly limited. Although studies have focused mainly on writing skills, little research has focused on wikis in mathematics education. Further research can be conducted to address the question of how wikis can

be employed in and out of school environment to improve the process of mathematics learning and teaching and whether wikis can be used as an alternative tool to teach mathematics.

8. References

Alm, A. (2006). "CALL for autonomy, competence and relatedness: Motivating language learning environment in Web 2.0". *The JALT CALL Journal*, 2(3).

Becker, H.J. (2001). *How are teachers using computers in instructions? Meetings of the American Educational Research Association: National Survey Report.* Irvine, CA: Center for Research on Information Technology and Organizations, University of California.

Ben-Zvi, D. (2007). "Using Wiki to Promote Collaborative Learning in Statistics Education". *Technology Innovations in Statistics Education*, 1(1).

Bingimlas, K, A.2017. "Learning and Teaching with Web 2.0 Applications in Saudi K -12 Schools". *The Turkish Online Journal of Educational Technology*, vol 15, issue 3.

Brown, J.A., & Manly, B.J.F. (1998). Restricted adaptive cluster sampling. *Environmental and Ecological Statistics.*

Cho, Y.H., & Huang, Y. (2014). Exploring the links between pre-service teachers' beliefs and video – based reflection in wikis. *Computers in Human Behaviour*, 35 (2014).

Cole, M. (2009). Using Wiki technology to support student engagement: Lessons from the Trenches. *Computers & Education*, volume 52, Issue 1.

Cuban, L., Kirkpatrick, H., & Peck, C. (2001). High access and low use of technologies in high school classrooms: Explaining an apparent paradox. *American Educational Research Journal*, 38(4).

Desilels, A., Paquet, S., Vinson, N. (2005). *"Are wikis usable?"* Conference proceedings of the 2005 International Symposium on Wikis held in San Diego.

Donnelly, D.F., & Boniface, S. (2013). Consuming and creating: Early – adopting science teachers' perceptions and use of a wiki to support professional development. *Computers & Education,* 68, 9-20.

Guth, S. (2007). *"Wikis in education: is public better?"* Conference proceedings of the 2007 International symposium on Wikis held in Montreal.

Jacobs, G.M. (2015). Collaborative Learning or Cooperative Learning? *Beyond Words,* 3(1).

Krebs, M., Ludwig, M., & Muller. (2010). "Learning Mathematics using a Wiki". *Procedia Social and Behavioral Sciences* 2(2010). www.sciencedirect.com.

Krebs, M., & Ludwig, M. (2009). Math learning with wikis. Conference of Technology in Mathematics.

Lai, Y.C., & Ng, E.M.W. (2011). Using wikis to develop student teachers' learning, teaching, and assessment capabilities. *Internet and Higher Education.*

Laborde, C. (2008). *Technology as an instrument for teachers*. Proceedings of the international commission for mathematics instruction centennial symposium. Rome, Italy.

Larussen, J., & Alterman, R. (2009). Wikis to support the "Collaborative" part of collaborative learning. *International Journal of Computer – Supported Collaborative Learning*, volume 4.

Lavicza, Z. (2010). Integrating technology into mathematics teaching at the university level. *ZDM Mathematics Education.*

Martin, P., & K. Premadasa. 2010. "Effective use of Wikis in College Mathematics Classes". *Systemics, Cybernetics and informatics,* volume 8, Number 6.

Mejias, U.A. (2006). "Teaching social software". *Innovate,* 2(5). http://www.innovateonline.info.

Mirk, S.M., Burkiewicz, J.S., Komperda, K.E. (2010). "Students perceptions of a wiki in pharmacy elective course. *Currents in Pharmacy Teaching and Learning*, vol 2, No 2, pp.72-78.

Mirzajani, H., Alizadeh,. K.H., Gorji, O.H., Zerafat, R., Saravi, H.R., & R. Alami, R. (2015). "Wiki, a New Wave of Innovation for Teaching and Collaborative Learning". *International Journal of Education & Literacy Studies,* vol.3 No.4.

National Council of Teachers of Mathematics (NCTM). (2000). "*Principles and standards of school mathematics".* Reston, VA: Author.

Rutherford, S. (2014). *Collaborative learning theory, strategies and educational benefits*. Nova.

Ruthven, K. (2008). Mathematical technologies as a vehicle for intuition and experiment: A foundational theme of the ICMI, and a continuing preoccupation. *Proceedings of the ICMI centennial symposium. Rome.*

Sebbowa, D., Ng'ambi, D., & Brown, C. (2014). "Using Wikis to Teach History Education to 21st Century Learners: A Hermeneutic Perspective". *CriStal,* volume, 2, issue 2.

Tachie, S.A. (2019). Challenges and opportunities regarding usage of computers in the teaching and learning of mathematics. *South African Journal of Education*, volume, 39(2).

Ulleberg, I., & Solem (2015). "Hvordan kan laerere bidra til deltakelse og matematisering I klassesamtalen I matematikk? In Helstad, K., Solbrekke, T.D., & Wittek, A.L. 2017. Exploring teaching academic literacy in mathematics in teacher education. *Education Inquiry*, 8: 4,318-336.

Vossen, G., Hagemann, S. (2007). *Unleashing Web 2.0: from concepts to creativity*, Morgan Kaufmann, Boston

Wheeler, S., & Wheeler, D. (2009). Using wikis to promote quality learning outcomes in teacher training. *Learning, Media and Technology,* 34(1).

Yilmaz, K. (2013). Comparison of Quantitative and Qualitative Research Traditions: epistemological, theoretical, and methodological differences. *European Journal of Education*, volume, 48, No. 2.

Zheng, B., Niiya, M., & Warschauer, M. (2015). Wikis and collaborative learning in higher education. *Technology, Pedagogy and Education*, 24(3), 357-374. DOI:10.1080/1475939X.2014.948041.

Zorko, V. 2009. “Using wiki technology to support student engagement: Lessons from the trenches”. *Computers & Education*, 52(1).