ISSN: 2519-5670

VOLUME 18(2)/2023

THE INDEPENDENT JOURNAL OF TEACHING AND LEARNING

Formerly The Journal of independent Teaching and Learning

(Pty) Ltd, Reg No, 1987/004754/07
THE INDEPENDENT INSTITUTE OF EDUCATION

A publication of The Independent Institute of Education

The Independent Journal of Teaching and Learning

The Independent Journal of Teaching and Learning (IJTL) is an education-focused journal, published twice a year, online and open access [ISSN 2519-5670 (Online)] by The Independent Institute of Education. The aim of the journal is to make a difference to educators at the primary, secondary and tertiary levels, providing a scholarly forum for academics and education practitioners to share research on teaching and learning. The journal as well as all submission and publication information can be found at https://ijtl.iie.ac.za/ .

The IJTL is intended to be a resource for education practitioners and researchers as it aims to provide useful, research-based resources and to provide a scholarly forum for academics and education practitioners to share in research on educational practices and teaching and learning at various levels.

The following contributions are considered for publication:

- Theoretical articles
- Research-based empirical, reflective or synoptic articles that would be of interest to education practitioners
- Review articles that critically examine research carried out in a specific field
- Discussion or advocacy papers
- Book reviews that comprise a clear and concise evaluation of recently published books.

The journal accepts Doctoral Abstracts, which include the link to the full text thesis, from researchers that have graduated with a PhD/Doctorate in Education in the last two years. These are not peer reviewed and are published in a separate section of the journal. Authors whose articles are published in the IJTL may only publish preprint versions thereof on platforms other than the IJTL.

Publisher
The Independent Journal of Teaching and Learning
is published by
The Independent Institute of Education (Pty) Ltd
ADvTECH House, Inanda Greens Business Park
54 Wierda Road West
Wierda Valley, Sandton, South Africa
www.iie.ac.za

Address for correspondence
Dr Brenda van Wyk
Managing Editor
The Independent Journal of Teaching and Learning
PO Box 2369
Randburg 2125
South Africa
E-mail: editor@iie.ac.za

Contents

Notes on contributors

Dr Carolien van den Berg is a senior lecturer at the Department of Information Systems at the University of the Western Cape (UWC), South Africa. She holds an MBA, an MPhil in Future Studies and a PhD in Information Systems. Her areas of research and expertise include digital social innovation, entrepreneurship, ethics and AI, future studies, small business development, digital strategy, and innovative pedagogies. She is currently involved in a transdisciplinary project that focuses on sustainable-smart innovations linked to SDG 11 in communities in Cape Town. Carolien has been a keynote speaker and panellist on several forums addressing digital inclusion and sustainability topics.

Dr Apostolos (Paul) Giannakopoulos (PhD, MEd, H.E.D, Datamatrix, BSc) is a retired academic since 2020. He taught mathematics for 10 years at secondary school and later transitioned to tertiary where he lectured mathematics to engineering students starting with the University of Johannesburg and later University of South Africa. He retired after 30 years of service at institutions of higher learning. He is currently an Associate Researcher at the University of Johannesburg. Paul has written more than 80 papers and chapters. He is a passionate researcher who believes that research is the best way to improve teaching and learning practices.

Professor Lorette Jacobs is the Chair or the Department of Information Science at Unisa, South Africa. Her interests range from records management to the use of ICTs in information practices, information literacy development, curriculum development and the improvement of teaching and learning practices in higher education. Her current research relates to transcending research paradigms to encompass an Afro-centric paradigmatic construct and exploring supervision models that are unique to the open distance e-learning environment. She has completed a D Litt Et Phil in Information Science and an MPhil in Higher Education. She is currently involved in the artificial intelligence project of InterPARES part of the International Council on Archives related to the access and use of digital records by ESARBICA citizens.

Professor Jogymol Alex Kalariparampil is a full Professor in Mathematics Education and Head of the Department of Mathematics and Sciences Education at Walter Sisulu University, South Africa. Her current research interests concern how mathematics pre-service and in-service teachers and school learners can be empowered through teaching, research, and community projects with local, national, and international partnerships by the Mathematics Education and Research Centre she established at WSU.

Professor Kakoma Luneta is a National Research Foundation (NRF) South Africa rated researcher and Professor of Mathematics Education in the Faculty of Education at the University of Johannesburg. His research interest is in Mathematics Teachers Education at Secondary and Elementary school; Mathematics/numeric cognition and Professional Development and Mentorship of Mathematics Teachers. He has taught mathematics and physics in various Northern and Southern African countries, the UK and the US and been appointed visiting professor at various universities. He has published five books, over 100 book chapters and articles in accredited journals and been invited keynote speaker at various international forums on mathematics and mathematics education and research. He is the Editor in Chief of the *African Journal of Teacher Education and Development* (ajoted.org).

Shaveen Maharaj is an academic at Durban University of Technology's Electronic and Computer Engineering department, South Africa. Adeptly blending a decade of industrial experience in oil refining, power generation, and agriculture with a zealous passion for higher education. Shaveen is a researcher with a doctorate in Business Administration, and a Master’s in Engineering, Business Administration, and Philosophy, fostering innovation at the nexus of technology and management.

Dr Lunga Xolisa Mantashe has a PhD in Education and is a lecturer in the Department of Accounting at the University of Fort Hare, South Africa. His research interests are in education policy and pedagogy, Recognition of Prior Learning, and articulation of academic programmes between different sub-frameworks in the education and training sector.

Dr Sibongile Simelane-Mnisi is a senior instructional designer in the Directorate of Higher Education Development and Support, Curriculum Development and Support: eLearning at Tshwane University of Technology, South Africa. She is a 21st-century teacher, instructional designer, curriculum developer, risk-taker, collaborator, researcher, author, online facilitator, life-long learner, community builder, and leader. She is passionate about research. Her research interests are educational technology, mobile learning, e-Assessment, emerging technologies, learning management systems, education 4.0 tools relating to virtual reality, augmented reality, artificial intelligence, mathematics education, and general education. She supervises postgraduate students in the fields of Educational Technology, Technology Vocational Education, Mathematics, Science and Technology, General education, and a Master’s in Business Administration (MBA). Sibongile is the co-author of *Teaching with ICT*. She has authored and co-authored research articles, and chapters in books published in South African and international peer-reviewed journals. She is a member of the Southern African Research and Innovation Management Association. She is the chairperson of the Higher Education Development and Support Research and Ethics Committee as well as a member of the institution's research ethics committee.

Dr Siphamandla Mncube is a lecturer in the Department of Information Science at the University of South Africa (Unisa). He holds a Phd in Information Systems (University of Cape Town); master’s in information science (Unisa); Bachelor and Honours in Information Science (University of Zululand). Siphamandla’ s experience in this institution framed his academic journey and shaped his research niche areas. His research niche areas lie in ICT4D, Information Systems, Information Science, Open educational resources, Open Access, Adoption of technology models, Domestication Theory, Grounded theory, Web technologies, Internet of things, artificial intelligence, Virtual learning, Open distance e-learning. He supervises masters and doctoral students in the field of Library and Information Science and ICT-related topics.

Ntokozo Kintosh Nogobo is a full-time lecturer in Mathematics Education at North-West University, South Africa. He has completed his Master of Education (MEd) specialising on Mathematics Education at Walter Sisulu University. His research interest is on Mathematics self-concept and its consequent impact on Mathematics achievement and other aspects.

Ishmael Nyirenda, a PhD scholar at Rhodes University's Faculty of Education, South Africa, uses his experience with digital technologies in higher education to research the use of mobile technologies in teaching and learning. His goal is to understand how the users of mobile technologies self-regulate learning and effective technology integration and teaching higher education.

Dr Shamola Pramjeeth is the Deputy Head of School of Management at the IIE's Varsity College, a brand of the Independent Institute of Education (IIE), South Africa. She is responsible for the academic management of the higher certificate and postgraduate qualifications within the school across nine campuses. Shamola is a seasoned academic with over 17 years of experience in academia. Her career spans across both academia and industry, allowing her to bring a wealth of industry knowledge and practical experience into her classroom. Her qualifications include a Bachelor of Commerce Degree in Marketing and Business Management, a Bachelor of Commerce Honours in Marketing, a Master of Commerce in Management, and a PhD in Leadership. Shamola is a published author, lecturer, supervisor and external examiner for Honours and master's dissertations and a reviewer for academic conferences and two accredited DHET journals. Shamola contributes towards the body of knowledge in Management, Marketing, Leadership and Teaching and Learning in Higher Education fields through the development of academic qualifications, curriculum development, authoring of textbook chapters and peer-reviewed publications, and postgraduate supervision. Her research interests include management, marketing, leadership, sustainability, higher education teaching, learning and assessments.

Priya Ramgovind is a Senior Head of Programme in the Faculty of Commerce at The Independent Institute of Education (IIE), South Africa, specialising in Supply Chain Management (SCM). Priya completed a Bachelor of Business Science and a Master of Commerce in SCM, a Postgraduate Diploma in Higher Education. She is now pursuing her PhD in SCM. Priya contributes to the broad SCM and educational discipline through the development of academic curricula, the authoring of textbook chapters and various research publications. In addition, Priya has presented original research at local and international conferences, serves on advisory boards, and is an academic examiner and external reviewer for various Higher Education Institutions.

Dr Clement Simuja, a Senior Lecturer at Rhodes University's Faculty of Education, has spent a decade researching the integration of digital technology into schools, universities and adult learning. His research involves the intricate interaction between content, pedagogy, and technology in digital education, specifically concerning the obstacles encountered in technology-based education implementation.

Dr Belinda Verster is a registered professional urban planner and senior lecturer at the Cape Peninsula University of Technology, South Africa. She engages in collaborative inter- and transdisciplinary research, innovation and decision-making within the sustainable-smart cities realm. Her current research focus is on a research agenda for displaced marginalised communities and post-qualitative research on co-creating social digital innovations in vulnerable communities.

Editorial

Dolina Dowling

2023 is a year in which the devastating effects of climate change (such as the wildfires in the Mediterranean, Freddy, the longest-lasting cyclone in the Global South, and the severe weather events and flooding in the US) have been at the forefront of the news. Countries' commitments to goals made in the Paris Agreement 2018 and the UN Framework Convention on Climate Change, and the subsequent COP (Conference of the Parties) conferences are under stress. The war in Ukraine has resulted in many countries turning to coal-fired plants in the short term for energy security. Nevertheless, most societies are seeking ways to lower the impact of carbon fossils and to employ clean energy. International organisations continue to stress the need for governments to engage all stakeholders on policies and actions relating to climate change.

The importance of meeting UNESCO's Education for Sustainable Development (ESD) 2030 goals cannot be underestimated. 'ESD gives learners of all ages the knowledge, skills, values, and agency to address interconnected global challenges including climate change, loss of biodiversity, unsustainable use of resources, and inequality' (UNESCO Report 2023)

The outpouring of research on the abrupt move to online learning necessitated by the Covid-19 pandemic, with the concomitant analysis of what works and what does not, presents an opportunity to use the lessons learned when incorporating ESD into learning frameworks. Online learning in higher education is here to stay with many programmes being offered entirely in this mode and even more in a blended learning approach. The advantages for students are many; for example, it enables 'anywhere anytime' learning access. The use of mobile technology in learning has the potential to democratise higher education. Of course, many severe challenges remain particularly in sub-Saharan Africa such as the digital divide, poorly prepared students due to dysfunctional school systems and rampant poverty. All of these have been well addressed in previous editions of the IJTL.

The Interdisciplinary Collaborative Online Learning Framework Education (ICOL) of 2020 serves as a useful starting point in the quest for ensuring sustainable development is part and parcel of education programmes. The integration of ESD into ICOL is pursued in the first article of this edition. Using literature review as well as student reflections, the authors seek ways in which ESD can be practically implemented in interdisciplinary collaborative projects. They propose a new learning framework - the Sustainable-Smart Transdisciplinary Learning Framework - which includes a fifth learning design principle and a fourth structuring element. This is an important contribution.

In the following four articles, the use and implementation of online learning is explored. Given the rapid switch to online learning due to the pandemic, it unsurprisingly emerges that institutions were largely unprepared for this mode of learning as a principal learning tool. Nevertheless, as the articles show, there were successes as well as challenges.

In the first of these, the author investigates the impact of the shift to online teaching during COVID-19 on lecturers' attitudes and practices. To address the continuing challenges, the authors suggest an institutional training process so that lecturers develop the skills and cultural capital for effective online teaching. The findings are similar to that of the next article in which the author conducted a study on the challenges educators faced during the pandemic. Recommendations are provided to improve the effectiveness of online teaching practices. The following article may provide a way forward to have successful online teaching programmes. The authors explore the perceptions of academics in a university of technology on continuous professional development on the creation and teaching of online modules. Two factors were found critical to success; (i) the module structure provided by the instructional designer, and (ii) the support provided by the university's eChampions. The last article on online teaching investigates the widespread use of mobile technologies and their integration into education. The study expands on current knowledge as well as providing suggestions for practitioners in HEIs.

Online assessment is the topic of the following two articles. In the first of these, the authors use collaborative autoethnography to explore ways in which online proctoring tools can contribute toward ensuring valid and reliable summative assessments. While opportunities are found, the use of proctoring tools to ensure ethical behaviour of students is not established. The authors make recommendations in this regard. Following on from this, is an investigation into students' perceptions of Computerised Adaptive Testing (CAT) in higher education. The authors in this quantitative study found that most students are positive about using CAT. The findings are useful for institutions which are looking to implement CAT.

The last two articles are concerned with mathematics and success. The authors in the first study investigate the impact of socio-economic status on learners' self-concept in relation to mathematics in rural and urban schools in a district in South Africa. The study found that a parent's poor socio-economic status negatively affects a learner/student's self-concept in relation to mathematics. Recommendations are made to improve this. In Practitioners' Corner, the authors investigate the high dropout and failure rates in a Linear Algebra module at an Open Distance eLearning institution. Using script analysis, it was found that declarative and procedural knowledge was lacking, and that deep learning is not taking place. These are needed for academic success.

Integrating education for sustainable development into a sustainable-smart transdisciplinary learning framework[1]

Carolien van den Berg, University of the Western Cape, South Africa
Belinda Verster, Cape Peninsula University of Technology, South Africa

ABSTRACT

Education for Sustainable Development (ESD) has been gaining traction as a promising approach for addressing social challenges and driving positive change within society. The purpose of this article is to explore how ESD can be foregrounded to reframe and enrich an existing learning framework called the Interdisciplinary Collaborative Online Learning Framework (ICoL). The ICoL framework has been developed since 2020 using a Design-based Research methodology. Literature on ESD lacks exploration of practical implementation for interdisciplinary collaborative projects within communities. This article interrogates the question of how to integrate ESD within the ICoL learning framework. This study is explorative, and data are drawn from a review of the literature and student reflections. A qualitative, themed analysis of the data revealed a fifth learning design principle and a fourth structuring element towards a new learning framework, called the Sustainable-Smart Transdisciplinary Learning Framework.

Keywords: education for sustainable development, sustainable-smart, transdisciplinary learning, social digital innovation

INTRODUCTION AND BACKGROUND

Foregrounding sustainability within universities has become essential, especially under conditions of ever-growing scarcity of resources and the threat of human-made and environmental disasters. Higher education and universities are responsible for societal transformation (Žalėnienė & Pereira, 2021) and should be at the forefront of driving Education for Sustainable Development (ESD). The target is to enable a collaborative effort from all stakeholders in sustainable development initiatives, to foster responsible behaviour, and encourage individuals to actively participate in shaping a sustainable future. 'Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (Bruntland, 1987: 66).

Due to the multitude of socio-eco-political demands being placed on universities, driving education for sustainable development (ESD) lacks momentum, particularly in the African context (Manteaw, 2012; Dipholo & Biao, 2013; Tikly, 2019). Literature on ESD is focussed on a top-down (institutional and

[1] Date of Submission: 31 January 2023
Date of Review Outcome: 3 August 2023
Date of Acceptance: 20 August 2023

educational policy level) but is limited at a bottom-up (community) level. This article attempts to bridge this gap by engaging the ESD approach to reframe and enrich an existing learning framework referred to as the Interdisciplinary Collaborative Online Learning Framework (ICoL) (van den Berg & Verster, 2022a).

Within the above context, we reflect on a longitudinal Design-Based Research (DBR) study to move towards future learning spaces where ESD becomes a central concept entangled in learning. The study commenced in 2020, where design principles from the ICoL framework are tested and refined in practical student projects. These projects are interdisciplinary among Information Systems and Urban and Regional Planning students at two universities in Cape Town, South Africa. The focus of the student projects is to explore community-based environmental challenges and develop innovative technological prototypes to solve these challenges.

This article commences with a review of relevant literature on the topic of ESD to find meaningful ways of embedding it in the learning framework by exploring key concepts that have emerged over the previous iterations. The current ICoL learning framework is discussed and applied in a review of the data from the second iteration of this DBR study to highlight the shortcomings. Recommendations to refine the framework are subsequently provided for the third iteration to develop a sustainable-smart transdisciplinary learning framework if offered as a conclusion.

LITERATURE REVIEW

Education for Sustainable Development

Education for Sustainable Development is a holistic approach to education that drives sustainable development from a social, economic and environmental point of view (Vilmala et al., 2022). The traditional function of universities, as knowledge institutions is, evolving due to the growing challenges related to sustainability coupled with the demands of massification, globalisation, marketisation, and digitisation (Rosak-Szyrocka et al., 2022). The implementation of ESD depends on implementing interdisciplinary projects that integrate sustainability principles among university staff and their local and wider communities. This research area is constantly advancing, and more research is needed to understand the full extent of the benefits and challenges of ESD.

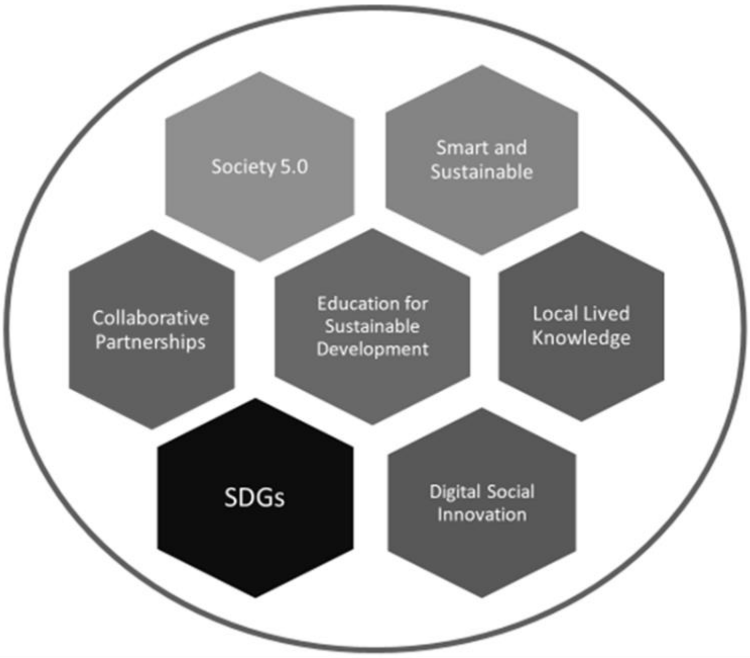
Some key insights on a roadmap to implement ESD include a focus on transformative action from learners and how individual learners are exposed to a sustainable future. Furthermore, structural change is required to address the fundamental causes of unsustainable development which requires an equilibrium between economic growth and sustainable development. ESD has to respond to the opportunities and challenges presented by a digital future whereby current problems may be alleviated whilst new challenges and risks will arise (UNESCO, 2020).

Incorporating ESD in learning environments includes a mix of different approaches that focus primarily on mainstreaming sustainability concerns in a more inclusive and participatory environment. Learners must become accustomed to the critical review of received knowledge and be supported by learner-led re-visioning activities. It is important to shift to networked learning over time within practical change projects that include cross-disciplinary approaches (O'Donoghue, Taylor & Venter, 2015). This can lead to the empowerment of learners 'with knowledge, skills, values and attitudes to take informed decisions and make responsible actions for environmental integrity, economic viability and a just society' (Leicht, Heiss & Byun, 2018: 7). To this end, ESD is often viewed as an 'action competence approach aiming at empowering students to take action to tackle with complex issues related to sustainable development' (Sinakou et al., 2019: 5994).

We interpret the holistic approach of ESD through several key concepts (see Figure 1), as it pertains to our disciplines of Information Systems and Urban Planning, and our context in the global South.

Figure 1:

Concepts to embed ESD in inter/transdisciplinary collaborative learning spaces



Society 5.0

The goal of Society 5.0 is to build an inclusive society that addresses societal constraints through emerging technologies. Whilst it is a new concept with limited application in Africa, the principles of leveraging technology for social good, inclusivity, and sustainable development align with the continent's goals and challenges (Ulmer & Wydra, 2020). The philosophic underpinning thereof of an equal and just society is incorporated to enable students to think about their future role as urban planning and information systems professionals dealing with our local and unique challenges in Africa. It strongly emphasises sustainable development and how to build the necessary capability and learning agility to successfully address the goals for sustainable development (Mishra, Thakur & Singh, 2022; Smuts & Van der Merwe, 2022).

The concept of Society 5.0 is to embed a human-centred approach to technology transformation taking the rapidly evolving technologies that Industry 4.0 employs for production within businesses and integrating them more deeply into the everyday lives of ordinary people (Gladden, 2019; Salgues (2018) provides insights by categorising Society 5.0's characteristics as the complete application of information and communication technology (ICTs) centred on common values that foreground community, people participation, sustainability and inclusivity. The goal is to build a society in which societal constraints are addressed by emerging technologies such as 5th-generation/6th-generation communication systems, IoT, AI, and big data, with other emerging communication, computing and sensing/actuation technologies into everyday life (Mishra et al., 2022).

Of special importance for this study is that Society 5.0 firstly emphasises community engagement and secondly that it is built on the ideals of sustainability. According to Kasinathan et al. (2022), Society 5.0

facilitates the accelerated progress of SDGs through the use of technologies. This provides an entry point in engaging with this concept in the higher education context and specifically how to incorporate this into individual learning spaces. The aim is that students need to be able to think critically, constructively and creatively under extreme conditions of rapid and severe changes.

A major contribution that incorporating Society 5.0 into education in general and learning environments specifically brings is its ability to integrate many complex elements such as the biophysical environment, society, economy (sustainability dimensions) and technology (smart). The philosophy of Society 5.0 instils a sense of social responsibility in students, inspiring them to actively engage in social change and contribute to achieving the SDGs.

Sustainable-smart innovations

Co-creating sustainable-smart innovations refer to the process of bringing together various stakeholders from academia, industry, government and the community, to jointly develop and implement sustainable and technology-enabled solutions. The focus of the study is on the application of digital technology particularly software applications to address challenges within marginalised communities. The emphasis is not solely on the technology itself but on the collaborative process with diverse stakeholders to co-create a more sustainable and equitable society, ensuring access to resources and opportunities for everyone's well-being. It is becoming increasingly important to design technology-enabled solutions that comply with constitutional and cultural values to limit potential damage to society (Helbing et al., 2021). Friedman and Hendry (2019) appeal for a value-sensitive design approach that values more than efficiency and economic growth in societies. Technology solutions should advance a human-centred society that balances economic progress with the resolution of social issues (Mishra et al., 2022). Aspects such as environmental conditions and health, safety and security, human dignity, well-being and happiness, privacy and self-determination (autonomy, sovereignty, freedom), fairness, equality, justice, consensus, peace, solidarity, sustainability, and resilience, all need to be considered (Friedman & Hendry, 2019; Helbing et al., 2021).

Sustainable-smart innovations emphasise a shift to Society 5.0 as mentioned above where innovations benefit all parties involved, whether they are consumers, workers, investors, the environment, or society (Mishra et al., 2022). This approach emphasises collaboration, active engagement, and co-creation of knowledge and solutions among stakeholders to achieve sustainable development goals. Projects that are linked to the community enable students to appreciate the impact of their discipline in local and global social contexts hence enabling high-impact learning (Strachan et al., 2019).

'Street-smart' local (lived) knowledge

Local knowledge or local knowing, in the context of this paper, refers to the know-how derived from the day-to-day lived realities of community members. In the rapidly changing social context of informal settlements in Cape Town, South Africa, this understanding of local (lived) knowledge does not necessarily refer to the traditions and cultural knowledge or indigenous knowledge (Antweiler, 1998: 469) that is typically associated with literature with this concept. Here we are referring to a 'knowledge-for-survival' that is learned at a fast pace and on the streets of informal settlements.

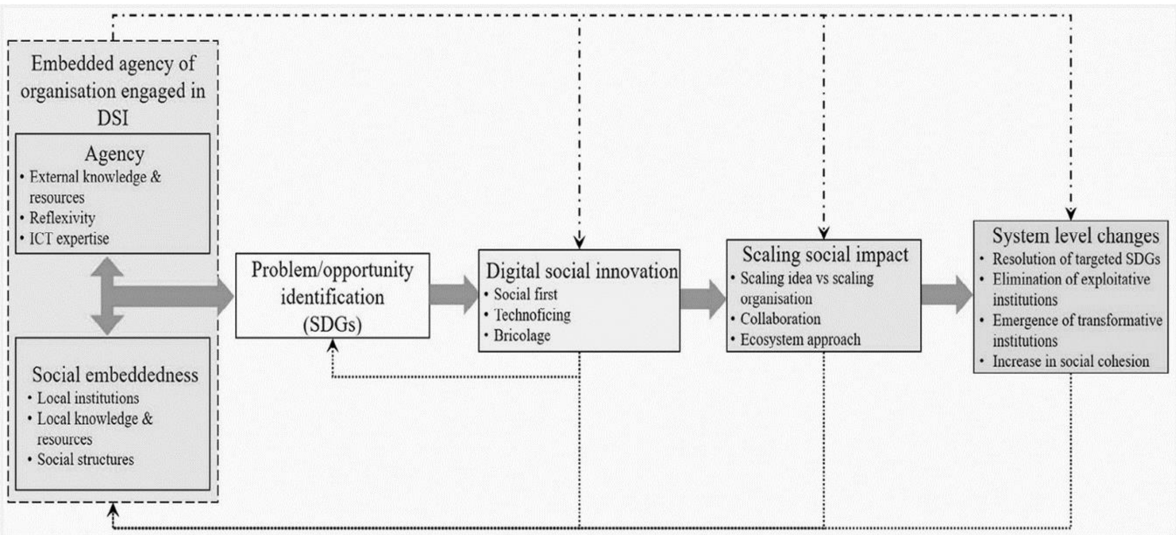
One of the key principles of ESD is the recognition of the value of local lived knowledge by valuing the intimate understanding that local communities often have of their environment and the challenges they face, and that this knowledge should be used to inform and guide sustainable development efforts (EUA, 2021). There are numerous examples of local lived knowledge providing valuable insights and practical solutions for sustainable development challenges, especially in the non-governmental sector (NGO) (Hill et al., 2020). In such examples, local communities are involved in the identification, design and implementation of solutions to ensure that such solutions are tailored to the unique context and are more likely to be adopted and used effectively. We consider ESD as a way of integrating street-smart local (lived) knowledge into the mainstream learning spaces of higher education as one of the fundamental, but untapped, knowledge resources. ESD encourages active community engagement, and incorporating local knowledge can strengthen the connection between education and community development (Zidny, Sjöström & Eilks, 2020).

Digital social innovation

Digital social innovation (DSI) has been gaining attention in recent years as a promising approach for addressing social challenges and driving positive change within society. The digital dimension is the integration of emerging technologies in services to society. The social dimension needs to be the focal point and not the technology. The innovations should provide solutions that are more effective, sustainable and ethically adequate than those that are in place today (Serpa & Ferreira, 2019). DSI applies to projects that use digital technologies in conjunction with community engagement and collaboration, co-creation strategies and bottom-up approaches to address societal needs. At its core, DSI leverage digital technologies to generate positive social impacts, the aim is to explore innovative, effective and sustainable solutions to pressing societal challenges, for example, those listed in sustainable development goals (SDGs) (Qureshi, Pan & Zheng, 2021). However, in comparison to the use of ICTs for commercial use, digital transformation in the social space has been less dramatic, particularly in solving wicked social problems as identified under the SDGs (ibid., 2021). An overview of the process is illustrated in Figure 2.

Figure 2:

Process of digital social innovation



Qureshi et al. (2021)

As shown in Figure 2, DSI emphasises the importance of agency and social embeddedness by prioritising ‘social issues over technological finesse’ or ‘pursuit of social objectives using a technology that is good enough and appropriate for the purpose outreach to collaborate in the co-creation of solutions' (Qureshi et al., 2021: 654). This position is shared by ESD with its human/people-centred approach where social challenges are the drivers and not the technological solutions.

The sustainable development goals

The 17 SDGs were designed by considering a holistic view of sustainable development to benefit humanity and the ecosystem (United Nations, 2015). They involve the elements of human development, the economy, technology, resources, and environmental changes integrated into the path of sustainability. They are indeed complicated goals to achieve, and the uncertainties involved are unprecedented and cannot be quantified (Kasinathan et al., 2022). To realise their potential, in recent years a shift has occurred that emphasises the SDGs not only as global initiatives but rather as focussing on their localising potential (Jiménez-Aceituno et al., 2020; Moallemi et al., 2020). The localising potential has been the focus of the longitudinal student project that this paper draws from (van den Berg & Verster, 2020; 2022).

The impact of universities on the SDGs requires collaborative efforts between local higher education institutions and securing funding for community-oriented research, interdisciplinary research and outreach activities that facilitate the dissemination of diverse pedagogical approaches and influence broader public opinions (Rosak-Szyrocka et al., 2022). Furthermore, Žalėnienė and Pereira (2021), emphasise the importance of effective management and governance practices that incorporate SDGs principles into university operations; and cross-sectoral dialogues, showcasing an institutional commitment to the SDGs, and affirming public dedication (Žalėnienė & Pereira, 2021). A comprehensive sustainability education should prioritise a thorough understanding of the intricate interplay between social, economic, and environmental systems; recognition of the inherent interdependence of these systems for the realisation of a sustainable world; and an appreciation for the diversity of perspectives and strategies in addressing complex challenges (Wheeler, Hesselink & Goldstein, 2015). Thus, tailored curricula are indispensable to ensure effective learning about the SDGs.

Our focus is on SDG 11 (sustainable cities and communities) (United Nations, 2015) as the initial entry point for the student projects. However, it is emphasised that there needs to be a deep awareness of the interrelated nature of the SDGs and that none of them can and should be considered in isolation. This interrelated nature of the SDGs provides both an opportunity and an obstacle in learning spaces, the opportunity for students to negotiate real-world problems but with the complexity and uncertainty that this presents. This requires continuous awareness of the fine balance between powerful learning versus potential learning inertia.

Collaborative partnerships

The growing urgency to address the future of our societies and planet requires collaborative partnerships that co-create sustainable solutions whilst enabling the equilibrium between ecological, economic and social concerns (EAU, 2021). This complex endeavour calls for an inter/transdisciplinary focus to circumvent the narrow lenses of disciplinary boundaries. The application of a triple or quintuple helix approach can integrate different perspectives to set the stage for sustainability priorities and considerations (Carayannis & Morawska-Jancelewicz, 2021). In higher education for sustainability, this implies designing new sustainability curricula and programmes that position learning to collaborate as a key objective (Freeth & Caniglia, 2020; Tietjen et al., 2023). Creating a learning environment that foregrounds collaboration and interdisciplinary partnerships is complex. In the design and facilitation of the learning environment, it is crucial to expose learners to the challenges that can provoke discomfort in interdisciplinary teams. When the challenges experienced in and among groups override the benefits it can compromise the viability of interdisciplinary collaboration (Freeth & Canglia, 2020). This requires constant monitoring of group dynamics and assistance to students in the navigation of group dynamics, interpersonal relationships and community engagement. Managing group work is complex in itself more so within interdisciplinary and transdisciplinary teams.

The next section describes the Interdisciplinary Collaborative Online Learning (ICoL) framework designed to facilitate interdisciplinary collaborative learning environments.

The ICoL framework

The Interdisciplinary Collaborative Online Learning (ICoL) framework has gone through three development phases since 2020. The first-generation framework was based on a pilot study that focused attention on agency in communities and resulted in four design principles: relationality, reflexivity, responsiveness and recognition (van den Berg & Verster, 2020). The second-generation framework developed the four design principles as pedagogical propositions and proposed an enriched understanding of each by suggesting sub-principles (Verster & van den Berg, 2021). The third-generation framework saw a return to theory in the form of sociomateriality and combined it with the concept of Future Learning Spaces (FLS). Enriching the third-generation framework with the student experience resulted in the emergence of four redefined design principles for the complex interdisciplinary, online learning space, namely: (i) context-sensitive learning experiences, (ii) co-construct knowledge, (iii) socio-technical and socio-cultural entanglements and (iv) relationality and agency (van den Berg & Verster, 2022b).

During the engagement with sociomateriality and FLS, three elements, namely pedagogy, space-time activities and technology, that can be considered as providing structure to the learning space emerged. Simplified, pedagogy incorporates the approach to collaborative, interdisciplinary learning and how this applies to the different design principles. The incorporation of space-time is emphasised by Tietjen et al. (2023), as an important element because it is not only where learning occurs but also when. Our definition of space-time activities refers to the space (virtual and/or in person, campus and/or site-community, formal/informal) and time (pacing, synchronous and asynchronous, class time and out of class time, time on different activities) and the specifics and practicalities of learning activities. For each design principle, examples are provided in the ICoL framework for potential technology applications, methods and programmes that can be utilised. Figure 3 provides a high-level breakdown of the design principles and structural elements. Figure 4 provides further detail on the application of each structuring element.

Figure 3:

Design Principles and Structure Elements

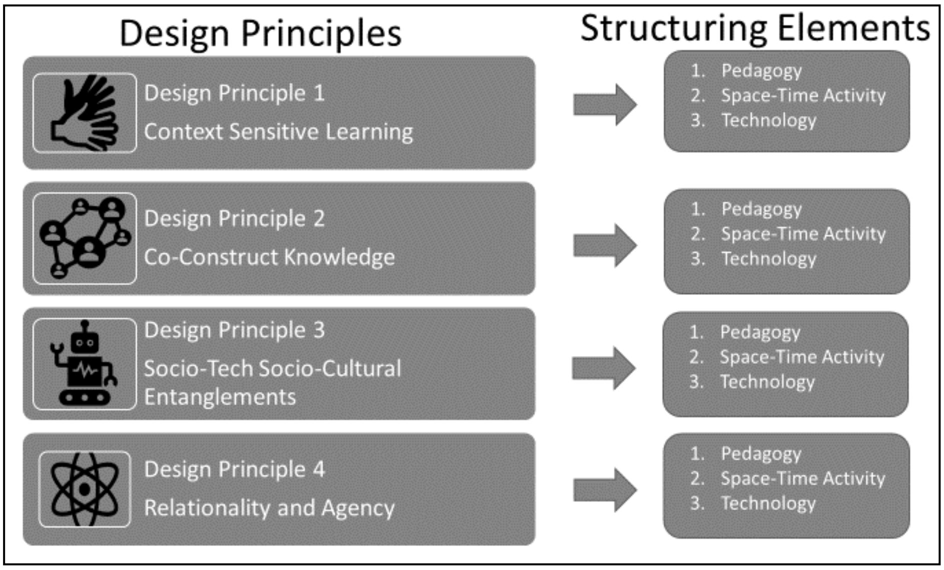
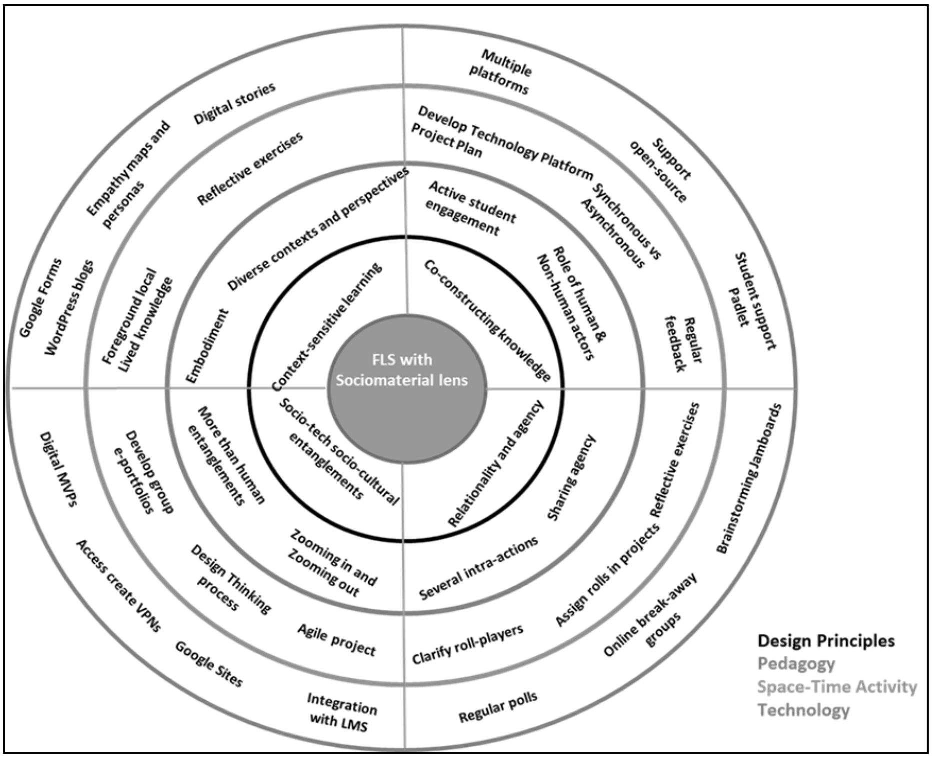


Figure 4:

The ICoL Framework



van den Berg (2022a)

As seen in Figure 4, the structuring elements for each design principle are depicted to first show the pedagogy followed by proposed space-time activities and examples of the application of technology in the outer rim.

RESEARCH METHODOLOGY

The research is taking place within the broader design science paradigm by applying a Design-Based Research (DBR) approach. In a DBR study, the researchers will first gain an in-depth understanding of a problem before any prototype solution is designed and tested (Mckenney & Reeves, 2020). DBR differs from other types of scientific inquiry because it simultaneously develops both theoretical insights and practical solutions, together with stakeholders within authentic settings (ibid., 2020). This study has developed both theory and practical application within an iterative process of testing and refining the design principles and structuring elements as depicted in Figure 4. The goal is to solve complex real-world problems in authentic situations by cycles of analysis, design, development, evaluation and redesign. The design is validated via practical use within iterative cycles that confirm findings and align theory, design and practice (de Villiers & Harpur, 2013).

A DBR study is longitudinal and consists of a collection of sub-studies that are reported separately. The purpose is to further refine the design and test this in the following iteration to finalise the learning framework. This study applies a four-phase method as espoused by Reeves (2006):

> Phase 1: Analysis of practical problems by researchers and other stakeholders in collaboration as well as a review of the literature.
>
> Phase 2: Development of solutions informed by existing design principles and technology interventions.
>
> Phase 3: Iterative cycles of testing and refining of draft design principles within practical settings.
>
> Phase 4: Reflection to produce Design Principles and enhance solution implementation.

The study is currently in Phase 3 and two iterations have been completed in 2021 and 2022 with a third and final iteration planned for 2023.

The study took place among academics and students from two universities in Cape Town, South Africa. Participants included 30 students from the Honours group in Information Systems (IS) and 24 students from the Advanced Diploma in Urban and Regional Planning (URP) during the second iteration in 2022. The group project was part of the overall learning outcomes and assessments of both modules and permission was obtained from students to have their findings and reflections included in the data. Both universities also obtained ethical approval for the overall study.

Students' comments were collected through a structured questionnaire that consisted of 25 closed and open-ended questions. The questionnaire was made available to students via Google Forms. A total of 51 responses were received. The questionnaire was structured to test the design principles and structural elements of the ICoL framework. The responses were analysed via a thematic analysis of each theme within the framework.

DISCUSSION: TOWARDS THE SUSTAINABLE-SMART TRANSDISCIPLINARY LEARNING FRAMEWORK

In this section, the four design principles implemented during the second iteration are presented. In the review of each design principle, a breakdown of the three structuring elements, namely pedagogy, space-time activity and the use of technology are analysed according to the evidence from the data. The objective of this section is to review the findings to identify the limitations in the current ICoL framework and to apply the key findings from the review of the literature coupled with student feedback to refine the framework further.

Design principle 1: context-sensitive learning

This design principle calls for the creation of immersive context-sensitive learning experiences by incorporating different interactive tools to open up the learning space to divergent viewpoints and cultural perspectives about problems in communities.

Pedagogy

The pedagogical drivers that underpin this design principle were developed in the previous iteration of the study and tested and refined in this iteration. They include 'embodiment' and 'awareness of diverse contexts and perspectives'. Embodiment recognises the continuous reconfiguration of social and material systems where students are exposed to the movement across physical and virtual spaces to enable them to tap into their own local lived (embodied) knowledge in the learning activities we design.

The COVID-19 pandemic presented the challenge that all activities had to be moved online and the benefits of a more fluid blended environment could not be explored. In a review of the impact, students were asked to reflect on whether they felt they could represent themselves in virtual spaces and the majority, 73%, felt that they could. The obstacles in a fully online environment that were highlighted included, for example:

> Taking in content via online learning is great, however, class discussions, debates etc, where most of the learning generally takes place, are lost. I also believe that this could have contributed to the team's misunderstanding/misinterpreting direction.

> Part of my personality can't be represented in online learning. This means that a key part of myself is not displayed to my classmates and lecturers.

In a review of students' perception of 'awareness of diverse contexts and perspectives', the majority felt that the experience of working in the interdisciplinary group assisted them in shifting their thinking. Some examples include:

> The different perspectives influenced my learning by enabling me to view situations from other people's positions and to consider other people's views, experiences and beliefs. This provided me with a deeper understanding and empathy which decreases prejudice, judgment, and conflict, given our problem statement was based on homeless people.

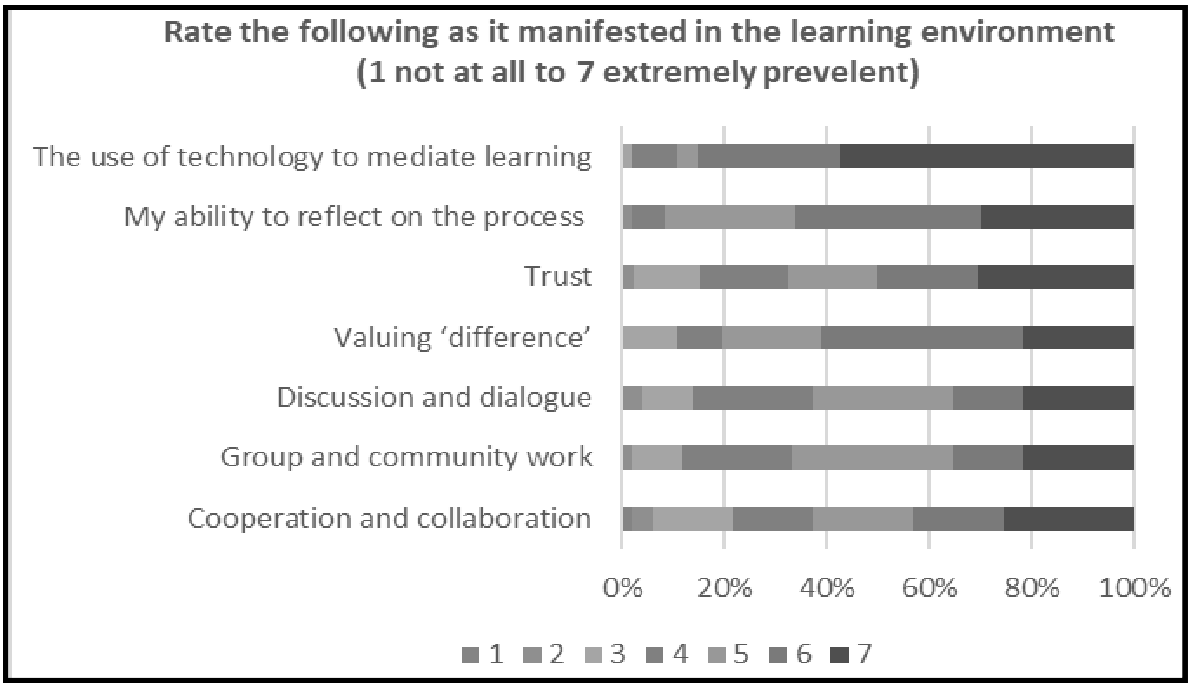
> A lot of the time I would view an answer one way but a group member who was different from me would help me to view things from a different perspective because of their personal experiences and background.

Space-Time Activities

A review of the perception of students regarding activities to stimulate context-sensitive learning is presented in Figure 5. It was essential to enable space and time for reflection on the learning as well as bringing in the students' local lived knowledge.

Figure 5:

Space-Time Activities for Context-Sensitive Learning



Students were asked to rank certain aspects that manifested in the learning on a scale from 1 to 7. The prevalence of an online learning environment emphasised the importance of technology as seen in Figure 5. It will be important to test this again in iteration 3 to determine the importance and also to ensure that an enabling environment for blended learning is created. The ability to reflect was prevalent, however, this was only requested at certain intervals during the project. In future iterations regular reflexive exercises and feedback on the process is required.

It is envisaged that more time will be spent actively working within the community in iteration 3 as we move to a blended learning environment with a focus on one specific area in Cape Town where the projects will be executed. A focus on more discussion and dialogue among the teams will also have to be strengthened.

Technology

The use of an online platform will continue as this proved to be very useful for cooperation among the groups. Students found this helpful:

> Google Docs was an excellent collaborative platform whereby my group was able to consistently share our findings.

The application of digital stories to show the problem from the communities' perspectives worked well and most groups found this to be a very useful tool to foreground the local lived knowledge residing within their communities:

> My biggest learning surprise during the project was on Personas and Digital stories. I never thought that we will get a chance to engage with the community and interview them, and shared the issues that they experienced in their communities. I am also surprised by the skills that I got already from this project like creating Digital stories and designing prototypes.

Design principle 2: co-construct knowledge

This principle focuses attention on the importance of considering all the role players (human and nonhuman) and their contribution to knowledge creation and developing relevant solutions. Co-constructing knowledge is not a simple feat and one that needs very careful and deliberate pedagogical, activity and technological decisions.

Pedagogy

It is important to ensure that there are opportunities for differing personality types to feel comfortable in the learning space to the point where they can freely contribute. The following student response made us aware of this issue:

> Working with people of different personalities was my biggest surprise. In my mind I did not think that introverts can work effectively with extroverts, to top it all when I heard that IS students are going to work with URP, I only thought of chaos and people misunderstanding each other. That worked out differently for me, the project was carried out effectively despite different personalities, backgrounds and different fields of study.

A further issue that shapes our pedagogical decisions is to be explicit in the value of bringing the disciplines of IS and URP together. The following student reflections show how students come to realise and value the contribution of each discipline through specific disciplinary knowledge, skills and values.

> My biggest learning surprise during this project was thinking the two disciplines, information systems, and urban & regional planning could never be linked. Secondly, acknowledging that different perspectives can help people to come up with great ideas to incorporate everyone that is affected.

> I underestimated the benefits that a different discipline could bring to your learning and how it could improve your knowledge.

We should map the knowledge areas that each of these disciplines, separately contribute to responding to the community problem (interdisciplinary) and then how we create new knowledge that is not attributed to only one discipline (transdisciplinary). This is an important shift to make in the enriched learning framework.

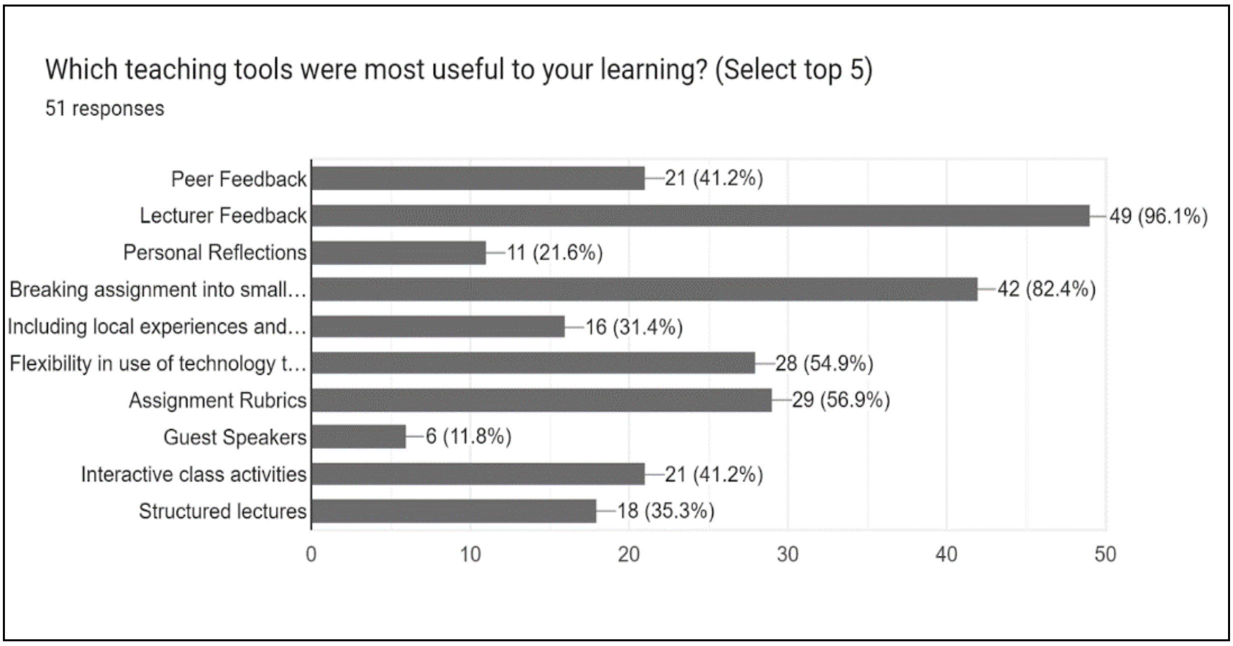
Space-time activities

One of the realisations that emerged from the data, was the lack of project management by the students to assign roles and responsibilities. In the next iteration, this should be incorporated into a Code of Conduct that will guide disciplinary and personal values, principles and ethics as well as the roles and responsibilities.

> We did not establish a group leader in our group project. It made it a bit more complex because no one would delegate work equally to the group members and others felt like they were putting in so much more work and effort than others.

A further essential consideration for co-constructing knowledge is ensuring opportunities for all voices to be heard and considered. As such a level of freedom should be allowed for student groups to negotiate their own choice of group engagement strategy, digital platforms, meeting times and places. We found one of the most valued lecturer activities to be feedback (Figure 6). Unfortunately, peer feedback scored very low, and this will have to be addressed in the next iteration as we value peer learning and need to scaffold it more constructively into the learning activities.

Figure 6:
The usefulness of teaching and learning tools available to the student groups

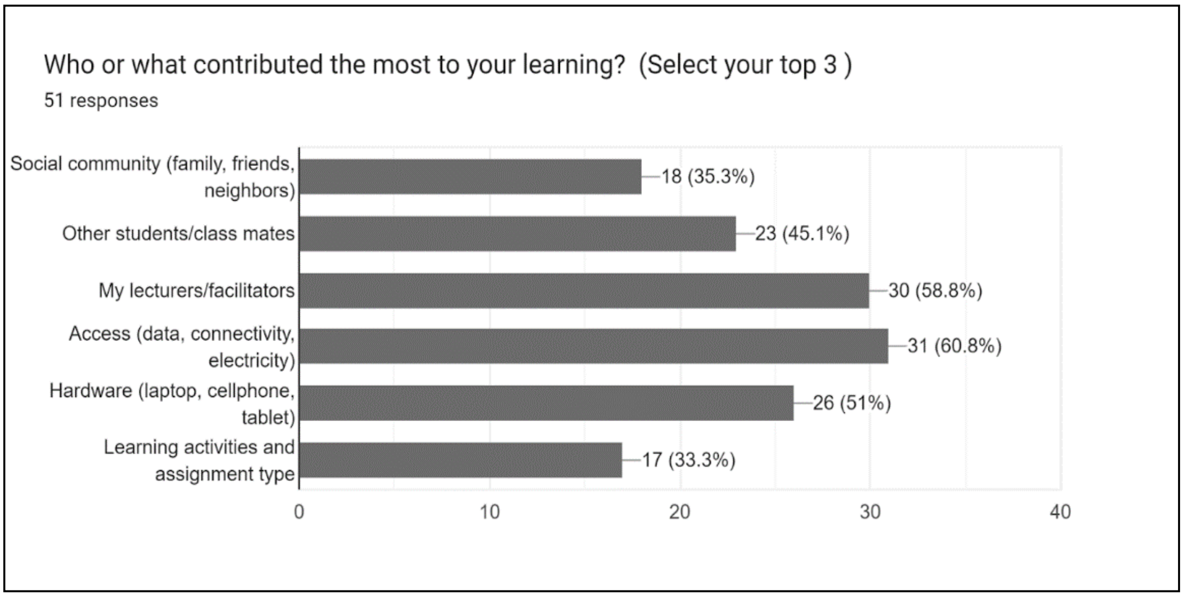


A serious concern as highlighted by Figure 6, is the seemingly meaningless activity of 'personal reflections'. This is concerning especially because we associate critical thinking abilities with being a reflective young professional. In the next iteration, the value of reflections will be emphasised and practised to upskill students in the art of critical reflection.

Technology

Technology was the most important enabler for the students to co-construct knowledge. This is clearly indicated in Figure 7 with two of the top three rated elements being 'access' and 'technology hardware'. Students thus rely heavily on technology to contribute to their groups, and it would be worth watching how this issue shifts in iteration 3 with the move from a fully online to a blended learning space.

Figure 7:
Who (human) or what (nonhuman) contributed most during this project?



We found it encouraging that students, although reliant on technology within the online learning space, also realised the value of collaboration as per the following student reflection:

> There are several valuable lessons I learnt through collaborative group work, but perhaps the most essential is that it is not about technology or developing a strong project plan, it is about being able to work with very diverse individuals.

Design Principle 3: socio-technical and socio-cultural entanglement

This design principle incorporates the intra-action between the human and technology (socio-technical) and the complexities within the human and their socio-economic-cultural settings. Both forms of entanglement highlight the reciprocal relationships between humans, culture and technology, and how they co-create and co-constitute each other. It is important to recognise the emergence of knowledge and agency in a learning design that allows for matters of space, time, different digital tools and other artefacts to co-evolve.

Pedagogy

The pedagogy focuses on acknowledging the more than human entanglements within the space as well as a process of zooming in and out from the bigger macro environment to the micro-level activities (Nicolini, 2009). Zooming out calls for a deeper analysis of the macro-level such as the larger social, political, and technological systems that shape and are shaped by them and zooming in to the space-time activities related to the specific interactions and practices of individuals (Tietjen et al., 2023). The design of the learning environment further needs to emphasise the importance of 'more-than-human entanglements' that stresses the interconnected relationships between human and non-human actors within the system. This allows for a deepened, interconnected, reciprocal relationship between students, facilitators, community members, technology, the environment and other learning objects to co-create artefacts to recognise agency.

> My biggest surprise was how amazingly intertwined different professions can be in pursuit of eradicating environmental problems.

> How technology and Planning can integrate, I learnt a lot about how technology can help fix planning problems in society.

Space-time activities

In the design of the activities, groups were tasked to create an e-portfolio that included the entire project, and it became a 'living environment' of interaction and collaboration. By incorporating a design-thinking methodology, students were guided to explore the problem from different lenses to develop their capability to continually change and adapt their thinking. A further consideration is to provide the opportunity for groups to recalibrate, pivot or change. The project follows an Agile methodology with short sprints to accommodate change and flexibility with a focus on the process and not the outcome.

> I was not familiar with google docs before the assignment so I learnt a lot from also how to develop digital stories and prototypes and that you can change if something is not working.

Technology

In the design of technology, it is important to enable students to work anywhere and at different times to integrate the socio-technical environment. This is prevalent in a learning environment where you work with students from marginalised communities. Access through Virtual Private Networks (VPNs), open source and integration with the university's LMS is required.

> One constraint that prevented me from attending meetings was Load Shedding. However, there were always alternatives. Someone from the group would update the rest of us via WhatsApp Message.

> Although everything was fast-paced, I did not struggle to play an active role in my group. Through the use of Google Meets and WhatsApp, I was always present.

Design Principle 4: relationality and agency

ESD as well as the key concepts we draw from position society and communities at the centre of both education and the current and future role of technology (see section 2). It is strongly human-centred and as such recognises the power dynamics that exist. For us to engage with power dynamics within the learning space, we focus on recognising relationality and agency.

Pedagogy

Numerous conflicting experiences were captured in the reflections in the previous examples, and this will need to be addressed in iteration 3. Similar to the issue being raised under design principle 2, it is clear that a need exists to be explicit about the value being added by each discipline separately and what the potential gains are when the disciplines co-create knowledge. This has a direct impact on the level of empowerment an individual student or group experience and as such impact their level of agency. Problems expressed by students are for example:

> My biggest surprise is that people don't take my profession seriously. There were parts that a planner should know what to do and how to solve things, but we were being questioned and

> corrected on whether we are doing the right thing and whether our ideas are valid enough or not.

> Consensus becomes a huge constraint in a group because everybody wants their opinion to be heard even though it does not speak to the problem at hand.

> There were only two active planners, and the majority were IS students who knew each other. I felt unheard and dismissed at times.

Space-time activities

Giving agency to the community for whom you are trying to support is a challenge one can only appreciate when experiencing it first-hand. This is recognised by a student in the following reflection:

> My biggest surprise with this project was just how "difficult" it is to include the people whose problem you're trying to solve from the conception stages right up to the making of your prototype even though this is the best way to get inclusive results.

This level of realisation boasts well for the learning objective of developing abilities to collaborate with complex role players.

Technology

Students were very aware of the shortcoming of agency and its associated sense of responsibility within the online learning space. The technological shortcomings, as can be seen from the student reflections, were accentuated as 'silent online', 'misunderstanding and poor communications in the online environment', 'lazy online' and 'loadshedding (power blackouts)'

> I dislike the fact that people would casually stay silent online, especially when questions are asked or simply not trying to come up with an idea or say something at all.

> During online environments, there are a lot of misunderstandings that sometimes lead to serious arguments and people are very lazy online and make excuses about connectivity issues.

> My group had very poor communication. I believe that if it was face-to-face things would have been different. Some of the group members were forever busy during the assignment, I feel like some people take advantage just because things are done online and just decide to be busy and nowhere to be found. Load shedding also caused big havoc in the online environment.

The next iteration of this project would have to respond to the above concerns as technology is a double-edged sword where it can provide ample access and connectivity amongst group members but also act as a screen behind which responsibilities and contributions can be hidden.

RECOMMENDATIONS: THE SUSTAINABLE-SMART TRANSDISCIPLINARY LEARNING FRAMEWORK

The culmination of the above engagement with literature and student reflections on iteration 2 of the student project is three distinct shifts to the learning framework:

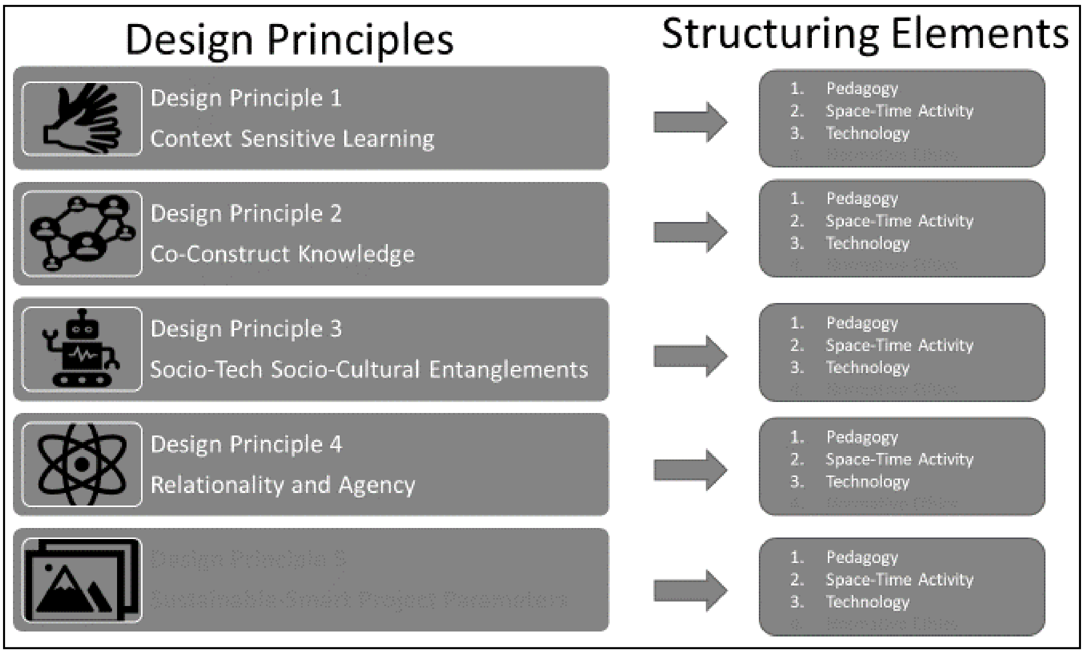
Shift 1: from an interdisciplinary learning space to a transdisciplinary space where students can engage with the value-adding abilities of transdisciplinary work. Fam et al. (2020) caution about the tension between disciplinary know-how and transdisciplinary knowledge, skills and values. Careful planning is needed in iteration 3 to negotiate and accommodate this complexity.

Shift 2: from an online learning space to a blended community-based learning space. As a result of the lifting of COVID-19 restrictions, it is possible to allow students both on campus and in communities. We have decided to focus our efforts on only one community (Dunoon/Potsdam Informal Settlement, in Cape Town, South Africa) and not spread our work amongst numerous communities to which our students had access.

Shift 3: this shift encapsulates the proposal of a new design principle as well as a new structuring element for the learning framework. The design principle, 'Sustainable-Smart Parameters' focuses attention on framing the student project within the sustainable-smart discourse where sustainability drives technology-enabled solutions. Sustainable-smart parameters are thus the fifth design principle that frames pedagogical, space-time activities and technology decisions made before, during and after the learning activity. The new structuring element, 'Normative Ethics', is understood to be referring to those issues that shape and influence one's ethical behaviour or the 'social ought to, thus what is acceptable in both the individual and the collective sphere. The social ought to transcend the professional space to also include the student's role as a responsible local and global citizen.

Figure 8:

The enriched learning framework with the addition of Sustainable-Smart Parameters as a new design principle and Normative Ethics as an additional structuring element



24

CONCLUSION

The article reviews the possibilities of embedding ESD to improve an existing learning framework developed in a DBR study that commenced in 2020. The purpose is to enrich current literature by contextualising ESD in a learning environment that foregrounds interdisciplinary collaborative learning within universities. The discussion incorporates a review of Society 5.0 through smart and sustainable designs that utilise local lived knowledge to design digital social innovations in collaborative partnerships that foreground the SDGs.

In the article, the design principles and structuring elements of the current ICoL framework are tested and refined through a review of the data from the second iteration. The aim is to develop theory and practical applications to enhance the ICoL framework to incorporate ESD.

Recommendations include a shift to a transdisciplinary space in the student project by actively engaging with multiple stakeholders within a community in Cape Town. This will be accomplished through the shift from an online to a blended learning approach. The third recommendation is to include an additional design principle to encapsulate specific sustainable-smart project parameters and to include an additional structuring element that features normative ethics within the learning framework. These changes will be tested and refined in the third and final iteration in 2023 to develop the sustainable-smart transdisciplinary learning framework.

REFERENCES

Brundtland, G. (1987) *Our common future: The world commission on environment and development*. Oxford, England: Oxford University Press.

Carayannis, E.G. & Morawska-Jancelewicz, J. (2021) The Future of Europe: Society 5.0 and Industry 5.0 as Driving Forces of Future Universities. *Journal of the Knowledge Economy* 13 pp.3445-3471.

Dipholo, K.B. & Biao, I. (2013) Rethinking Education for Sustainable Development in Africa. *World Journal of Education* 3(6) pp.46-53.

European University Association (EUA). (2021) Universities without walls. A Vision for 2030 (Report February 2021). https://eua.eu/resources/publications/957 (Accessed 3 October 2023).

Fam, D., Clarke, E., Freeth, R., Derwort, P., Klaniecki, K., Kater-Wettstädt, L., Juarez-Bourke, S., Hilser, S., Peukert, D., Meyer, E. & Horcea-Milcu, A.I. (2020) Interdisciplinary and transdisciplinary research and practice: balancing expectations of the 'old academy with the future model of universities as 'problem solvers' *Higher Education Quarterly* 74(1) pp.19-34.

Freeth, R. & Caniglia, G. (2020) Learning to collaborate while collaborating: advancing interdisciplinary sustainability research. *Sustainability Science* 15(1) pp.247-261.

Friedman, B. & Hendry, D.G. (2019) *Value Sensitive Design: Shaping Technology with Moral Imagination*. Cambridge, Massachusetts: MIT Press.

Gladden, M.E. (2019) Who Will Be the Members of Society 5.0? Towards an Anthropology of Technologically Posthumanized Future Societies. *Social Sciences* 8(5) pp.148-187.

Helbing, D., Fanitabasi, F., Giannotti, F., Hänggli R., Hausladen, C., van den Hoven, J., Mahajan, S., Pedreschi, D. & Pournaras, E. (2021) Ethics of Smart Cities: Towards Value-Sensitive Design and Co-Evolving City Life. *Sustainability* 13(20) p.11162.

Hill, R., Adem, Ç., Alangui, W.V., Molnár, Z., Aumeeruddy-Thomas, Y., Bridgewater, P., Tengö, M., Thaman, R., Yao, C.Y.A., Berkes, F. & Carino, J. (2020) Working with indigenous, local and scientific knowledge in assessments of nature and nature's linkages with people. *Current Opinion in Environmental Sustainability* 43 pp.8-20.

Jiménez-Aceituno, A., Peterson, G.D., Norström, A.V., Wong, G. & Downing, A. (2020) Local lens for SDG implementation: lessons from bottom-up approaches in Africa. *Sustainability Science* 15(3) pp.729-743.

Kasinathan, P., Pugazhendhi, R., Elavarasan, R.M., Ramachandaramurthy, V.K., Ramanathan, V., Subramanian, S., Kumar, S., Nandhagopal, K., Raghavan, R.R.V., Rangasamy, S., Devendiran, R. & Alsharif, M.H. (2022) Realization of Sustainable Development Goals with Disruptive Technologies by Integrating Industry 5.0, Society 5.0, Smart Cities and Villages. *Sustainability* 14(15258) pp.1-31.

Leicht, A., Heiss, J. & Byun, W.J. (2018) *Issues and trends in education for sustainable development*. Paris: UNESCO Publishing.

Manteaw, O.O. (2012) Education for sustainable development in Africa: The search for pedagogical logic. *International Journal of Educational Development* 32(3) pp.376-383.

Mckenney, S. & Reeves, T.C. (2020) Educational design research: Portraying, conducting, and enhancing productive scholarship. *Medical Education* 55(February) pp.82-92.

Mishra, P., Thakur, P. & Singh, G. (2022) 'Sustainable Smart City to Society 5.0: State-of-the-Art and Research Challenges' *South African Institute of Electrical Engineers* 113(4) pp.152-164.

Moallemi, E.A., Malekpour, S., Hadjikakou, M., Raven, R., Szetey, K., Ningrum, D., Dhiaulhaq, A. & Bryan, B.A. (2020) Achieving the Sustainable Development Goals Requires Transdisciplinary Innovation at the Local Scale. *One Earth* 3(3) pp.300-313.

Nicolini, D. (2009) Zooming in and out: Studying practices by switching theoretical lenses and trailing connections. *Organization Studies* 30(12) pp.1391-1418.

O'Donoghue, R., Taylor, J. & Venter, V. (2015) How are learning and training environments transforming with ESD? In A. Leicht, J. Heiss & W.J. Byun (Eds.) *Issues and trends in Education for Sustainable Development*. UNESCO pp.111-131.

Qureshi, I., Pan, S.L. & Zheng, Y. (2021) Digital social innovation: An overview and research framework. *Information Systems Journal* 31(5) pp.647-671.

Reeves, T.C. (2006) Design research from the technology perspective. In J.V. Akker, K. Gravemeijer, S.E. McKenney & N. Nieveen (Eds.) *Educational design research*. Routledge pp.86-109.

Rosak-Szyrocka, J., Apostu, S.A., Ali Turi, J. & Tanveer, A. (2022) University 4.0 Sustainable Development in the Way of Society 5.0. *Sustainability (Switzerland)* 14(23) pp.1-17.

Salgues, B. (2018) *Society 5.0: industry of the future, technologies, methods and tools*. London, Hoboken, NJ: ISTE Ltd. John Wiley & Sons, Inc.

Serpa, S. & Ferreira, C.M. (2019) Society 5.0 and Sustainability Digital Innovations: A Social Process', *Journal of Organizational Culture, Communications and Conflicts* 23(1) pp.1-14.

Sinakou, E., Donche, V., Pauw, J.B. De, & Van Petegem, P. (2019) Designing powerful learning environments in education for sustainable development: A conceptual framework. *Sustainability (Switzerland)* 11(21) p.5994.

Smuts, H. & Van der Merwe, A. (2022) Knowledge Management in Society 5.0: A Sustainability Perspective *Sustainability* 14(11) pp 6879.

Strachan, S.M., Marshall, S., Murray, P., Coyle, E.J. & Sonnenberg-Klein, J. (2019) Using Vertically Integrated Projects to embed research-based education for sustainable development in undergraduate curricula. *International Journal of Sustainability in Higher Education* 20(8) pp.1313-1328.

Tietjen, P., Ozkan Bekiroglu, S., Choi, K., Rook, M.M. & McDonald, S.P. (2023) Three sociomaterial framings for analysing emergent activity in future learning spaces. *Pedagogy, Culture and Society* 33(01) pp.17-36.

Tikly, L. (2019) Education for sustainable development in Africa: a critique of regional agendas. *Asia Pacific Education Review* 20(2) pp.223-237.

Ulmer, N. & Wydra, K. (2020) Sustainability in African higher education institutions (HEIs): shifting the focus from researching the gaps to existing activities. *International Journal of Sustainability in Higher Education* 21(1) pp.18-33.

United Nations. (2015) Transforming our world: the 2030 Agenda for Sustainable Development. United Nations General Assembly. New York, p.35.

UNESCO. (2020) *Education for Sustainable Development: A roadmap*. Paris. https://unesdoc.unesco.org/ark:/48223/pf0000374802 (Accessed 3 October 2023).

de Villiers, M.R. & Harpur, P.A. (2013) Design-based research – the educational technology variant of design research: Illustrated by the design of an m-learning environment. *Proceedings of the South African Institute for Computer Scientists and Information Technologists Conference ACM* pp.252-261.

van den Berg, C. & Verster, B. (2020, September) Co-Creating Social, Digital Innovation to Recognise Agency in Communities: A Learning Intervention: Research in Progress. In *Conference of the South African Institute of Computer Scientists and Information Technologists 2020* pp.85-93.

Verster, B. & van den Berg, C. (2021) Pedagogical propositions for interdisciplinary collaborative learning through social, digital innovation. *7th International Conference on Higher Education Advances (HEAd'21)* June 22-23.

van den Berg, C. & Verster B. (2022a). Towards a framework for interdisciplinary collaborative online learning spaces. 8th International Conference on Higher Education Advances, Valencia, Spain, 13-17 June 2022, http://ocs.editorial.upv.es/index.php/HEAD/HEAd22/paper/view/14577

van den Berg, C. & Verster, B. (2022b). Exploring Interdisciplinary Collaborative Online Learning Spaces through Sociomateriality in Cape Town, South Africa. *Electronic Journal of e-Learning* 20(4) pp.467-482.

Vilmala, B.K., Vilmala1, I.K., Suhandi, A, Permanasari, A. & Khumalo, M. (2022) A Literature Review of Education for Sustainable Development (ESD) in Science Learning: What, Why, and How. *Journal of Natural Science and Integration* 5(1) pp.35-44.

Wheeler, K.A., Hesselink, F. & Goldstein, W. (2015) Education for sustainability—looking backward and looking forward—IUCN CEC perspective on the United Nations decade of ESD. *Applied Environmental Education & Communication* 14(2) pp.70-81.

Žalėnienė, I. & Pereira, P. (2021) Geography and Sustainability Higher Education for Sustainability: A Global Perspective. *Geography and Sustainability* 2(2) pp.99-106.

Zidny, R., Sjöström, J. & Eilks, I. (2020) A multi-perspective reflection on how indigenous knowledge and related ideas can improve science education for sustainability. *Science & Education* 29(1) pp.145-185.

Online pedagogy: a changing higher education pedagogy and an emerging lecturer habitus(?)[2]

Lunga Xolisa Mantashe, University of Fort Hare, South Africa

ABSTRACT

This study explored how the shift to online pedagogy has shaped lecturer dispositions and practices for a post-COVID-19 era, including whether their practices during the national lockdowns could be conceptualised as temporary coping mechanisms or as an adoption of new practices related to effective modes of online teaching. Bourdieu's theory of human practices was employed to facilitate the exploration. The theory privileges the weight of past practices on agents while permitting incremental changes in such practices, depending on the flexibility and/or rigidity of a human habitus. Six lecturers were interviewed using semi-structured interviews to collect data. It was found that despite showing flexible and reflective dispositions regarding post-COVID-19 online teaching, participants were still in their exploratory phase in respect of teaching practices with online technology tools. An explicit institutional, reflective training process is suggested to help evolve in lecturers the habitus and cultural capital necessary to facilitate teaching with technology.

Keywords: online pedagogy, lecturer habitus, instant feedback, bodily invisibility

INTRODUCTION

In 2020, the world changed dramatically due to the Coronavirus pandemic (COVID-19). Overnight, COVID-19 and the subsequent global lockdowns forced universities to shift their teaching from face-to-face to online platforms (Blume, 2020). Teaching online offered a solution to lockdowns (Dhawan, 2020) on a temporary basis (Bozkurt & Sharma, 2021). Strictly speaking, the solution became Emergency Remote Teaching [ERT] (Hodges et al., 2020). ERT did not represent a conceptual shift to online platforms per se but a makeshift to save the academic year at the time (Hodges et al., 2020; Cutri, Mena & Whiting, 2020). Such makeshift decisions had implications for lecturer dispositions with regard to teaching strategies.

Bourdieu (2000: 149) theorises that:

> the existence of a *disposition*… is a basis for predicting that, in all conceivable circumstances of a particular type, a particular set of agents will behave in a [regular] way.

---

[2] Date of Submission: 27 January 2023

Date of Review Outcome: 16 July 2023

Date of Acceptance: 20 August 2023

On the strength of this theorisation, the change to online teaching practices displaced lecturer pedagogic habitus to a significant extent. This study was concerned with exploring the dispositions of lecturers and the latter's navigation of the change and transition from face-to-face to online teaching strategies. Given that lecturers were obliged to use technology in their teaching practices for two academic calendar periods, the study predicted the possibility of adapting to online pedagogies post-COVID-19 using the data collected. Essentially, this prediction was made on the strength of having explored the following questions:

1. How did the mandatory shift to online pedagogy shape lecturer dispositional schemata for a post-COVID-19 era?
2. How should the involuntary negotiation and navigation of online pedagogy by lecturers be conceptualised:
    a. As a temporary coping mechanism by a malleable and creative habitus?
    b. Or as an adoption of new notions about what is appropriate and effective modes of teaching and learning?

THEORETICAL FRAMEWORK

The study was framed through the work of Pierre Bourdieu. The sociologist, through the use of the concept of 'habitus', is concerned with showing that human practices tend to be repeated, because they have become deeply embedded in the human thought, behaviour, and action (Bourdieu, 2000). He defines habitus as 'embodied history, internalised as second nature and so forgotten as history' (Bourdieu, 1990: 56). It is produced by either 'birth or by a slow process of co-option and initiation which is equivalent to a second birth' (Bourdieu, 1990: 68).

This definition foregrounds quasi-consciousness and imperceptibility of the process of acquisition of a habitus. Indeed, when immersed in the field of its operation, habitus operates below the full conscious, deliberative, and calculative knowledge of an agent (Bourdieu, 1990). For the study, it helps underline the years in which lecturers were immersed in the old practice and the difficulty they faced during the COVID-19 crisis. Bourdieu says that habitus does not radically change when change occurs but evolves over time in response to new situations (Bourdieu, 2000). Given that the lockdowns were temporary, the study explored what was likely to happen to online teaching when lockdowns no longer existed.

Although no fixed timelines are fixed for the emergence of new dispositions, Bourdieu's (1990: 68) notion of 'practical sense' or 'feel of the game' constitutes a prerequisite criterion for immersion of agents in particular practices. However, the period of the lockdowns could not be important in itself, but only insofar as lecturers were willing to overturn weighty, old pedagogic practices and use the critical moment to explore and transition to new practices.

Hence, this paper entailed the consideration of most lecturers who had no history of teaching online, with technological tools at university. It took an initial view based on the theoretical framework that lecturers would have the tendency to prefer face-to-face teaching and learning. This was largely due to their lack of competence and knowledge (cultural capital) of working with technologies in the past. However, the results show that this was not necessarily the case.

LITERATURE REVIEW

The review of literature reveals challenges and opportunities to online pedagogy. It also engages the current empirical results relevant to intricacies involved in a lecturer habitus adapting to the use of technology and online pedagogies.

Challenges to online pedagogy

The key challenge is that higher education institutions in South Africa are not adequately prepared to teach using online platforms (Mashau & Nyawo, 2021; Czerniewicz, 2020). Also, increasing student engagement as demanded by online pedagogy remains a challenge (Dhawan, 2020). This arises from pedagogies that fail, amongst other things, to put the student at the centre of learning (Dlamini & Ndzinisa, 2020), lack of access to verbal cues (see Sathik & Jonathan, 2020) and the integrity of online assessments (Cutri et al., 2020).

Barriers to transition to online pedagogies

The first barrier concerns Instructional Design (ID). Deducing from various definitions, ID is a 'complex process' that integrates 'lesson preparation', pedagogic strategies, and student learning with 'instructional development' (Branch & Dousay, 2015: 15). For design to lead to successful online learning, it should also be a construction of both lecturers and students (Rapanta et al., 2020). ID must be aligned and respond to multivariate, complex educational contexts (Branch & Dousay, 2015).

Context includes, amongst others, student cognitive abilities; student socioeconomic circumstances; available infrastructure and inherent its inherent possibilities; cultural and social capital of students and lecturers to navigate online teaching and learning; and their embodied pedagogic dispositions with regard to the use of online platforms. Thus, the move to online platforms foregrounds careful design of online materials and activities (Rapanta et al., 2020; Dlamini & Ndzinisa, 2020).

In traditional face-to-face teaching, the notion of design does not hold centre stage and general use in higher education (Goodyear, 2015). During lockdowns, ID was neglected due to the speed of the shift to online platforms, thereby affecting proper training on ID principles for online and remote teaching and learning (Dlamini & Ndzinisa, 2020). Apart from design issues, findings from surveyed research studies reveal perceptual and practical barriers to transition to online teaching in that 'many faculty members and students do not see the value of fully online learning' (Hew et al., 2020:2). Despite evidence to the contrary, online learning is perceived to have low quality in comparison to face-to-face (Hodges et al., 2020).

It is said that students do not concentrate and interact with each other sufficiently online (Ulla & Perales, 2021). Lecturers have an impulse to want to go back to face-to-face teaching (Cutri et al., 2020). A large majority of lecturers do not want to exclusively teach online, even when they are happy with the training and technical support received (Pomerantz & Brooks, 2017). Finally, age also plays a crucial role. Older lecturers, for example, would likely prefer face-to-face to which they are accustomed (Pomerantz & Brooks, 2017). However, the claim neither takes account of the historical involvement of old lecturers with technology nor the individual rigidity or flexibility which Bourdieu considers vital for adapting to new circumstances.

Institutional and individual habitus in the changed circumstances

While change of lecturer dispositions can happen, there are difficulties associated with change in pedagogical practices (Feldman & Fataar, 2017). The difficulties can further be associated with the durability of the yet malleable habitus (Bourdieu, 1990). Durability gives weight to past practices; malleability gives credence to creativity of the habitus under new institutional conditions.

During lockdowns, it is reported that lecturers and tutors continued to use outdated pedagogic approaches, failing to adapt to the changing times (Nyawo, 2021). Pedagogic possibilities inherent in the university technological systems were not yet sufficiently tapped into (Dlamini & Ndzinisa, 2020). This was so because navigating online pedagogy requires the development of 'concepts that reflect underlying pedagogic principles' (Blume, 2020: 891) and a shift of lecturer dispositions to multivariate pedagogic practices (Dlamini & Ndzinisa, 2020).

Change has to be implanted in the habitus to ease integration of technological, online tools into pedagogic practices (Tarling & Ng'ambi, 2016). This further implies that lecturers must reflect critically on the assumptions they hold about the pedagogic processes in which they engage (Dlamini & Ndzinisa, 2020). Although useful for reflective purposes, dialogue about classroom practices, suggested by Ulla and Perales (2019), appears to elevate agency over structural and cultural constraints, in neglect of the entrenched nature of lecturers' view of teaching with (and embodying new) online pedagogies.

Evidently, the shift to online pedagogies demands adequate capacitation of lecturers with Information Communication Technology (ICT) skills (Nyawo, 2021) and the provision of training to help lecturers adapt to the demands of teaching in an online platform (Ulla & Perales, 2019). Knowledge of technology is not sufficient, nor is it synonymous with capacity to teach with it. Lecturers should move beyond using technology to teach in their traditional ways (Dlamini & Ndzinisa, 2020) to its use as a critical instrument that transforms the ways of teaching with it.

METHODOLOGY

A qualitative case study was conducted with the use of semi-structured interviews of six purposively chosen lecturers in one university in the Eastern Cape, South Africa. Given their flexibility, semi-structured interviews were used to collect data. It allowed the researcher to ask participants probing questions in order to extract rich data (Ruslin et al., 2022). Pseudonyms were used to report findings and discussions to protect the identity of participants.

Data were analysed using an inductive approach and thematic analysis. The analysis technique employed a latent approach to analyse data, focusing also on underlying meanings (Braun & Clarke, 2021; 2012). Thematic analysis is often used to identify and make sense of common, important experiences, behaviours, and actions amongst participants insofar as these are related to the purpose of a research study (ibid.). The study generated themes after a process of transcription, coding, and classification of data. The generation of themes was dependent on the frequency with which certain data sets were found (ibid.). The themes identified were important for illumination of the research question (Braun & Clarke, 2012).

Inductive thematic analysis was used during the identification of themes to avoid rigidly regarding as important only data reflecting exactly the research question; data drove the generation of themes (Varpio et al., 2019) and the researcher's worldview did not stand in the way of themes appearing from data (Braun & Clarke, 2006). While Bourdieu's framework largely featured in the interpretation of data, it was brought to bear without necessarily forcing data to conform to it in any blinkered way instead, data were allowed allow to lead as it was itself led by theory.

FINDINGS AND DISCUSSIONS

The disjuncture between the old habitus and the demands presented by the lockdowns are summed up thus: 'where there is no other way, you make the way, and you embrace it' (Rachel). 'Lecturers had to 'swim or sink and figure out a way to do it' (Liziwe).

They had to invent and adapt new (and nuanced) online pedagogic practices and strategies to address physical invisibility of students from lectures and the absence of instant feedback from students and overcome student engagement challenges. However, this was not a wholly successful process, as the results and discussion show below.

Reflection and practice

Prior to the pandemic, the department under study had been planning and reflecting on the need to use library 'recording facilities to try and do a few online lectures' (Sarah & Chloe).

This was largely sparked by the South African Institute of Charted Accountants (SAICA). SAICA's 2025 Competency Framework demands that students have digital competencies, thereby implying upskilling lecturers on digital skills (Sarah). This SAICA-induced change perhaps explains why no participant fundamentally opposed online teaching *per se*.

All reported plans above did not materialise because the uptake of technology use for teaching was completely undeveloped and almost non-existent prior to the lockdowns, consistent with the view that where there is an uptake, existing technologies are not sufficiently exploited during teaching (Bagarukayo & Kalema, 2015; Van de Heyde & Siebrits, 2019; Mashau & Nyawo, 2021; Nyawo, 2021). Blackboard was rather used mainly to deposit and communicate information to students.

Accounting for the above is a habitus-bounded imagination. The latter explains why Laura said that online teaching 'did not seem like something that would happen soon, easy, and quickly' despite characterising herself as 'a technology junkie'. It was her categories of thought that prevented her and others from seeing the possibility of online teaching happening despite reflecting and contemplating about it as departmental academics. Moreover, like many others, she had no history of teaching online and therefore had 'undeveloped' ideas about it; she had been 'toying with the idea of a flipped classroom' and the need for 'embedding multimedia using other available resources' before COVID-19. Interestingly, in the corporate sector Laura worked for, technology was embedded in the work she performed.

Her contemplative disposition and inaction illuminate the difference between familiarity with technology and actual knowledge and application of online pedagogic potentialities inherent in technological tools. The latter requires the possession of the Bourdieuan cultural capital and 'practical sense' peculiar to teaching with technology, which many participants did not have. In other words, dispositions can remain potential if they are not applied in real practice (Bourdieu, 2000).

Liziwe, on the other hand, had a history of using technology. She used blended learning in her previous university, using technology tools like 'PowerPoint with a voiceover recording' to teach 'complex concepts'. She also taught a Sage Business Cloud course which embedded technology and was completely done using technological material. Unlike Laura, she had practical knowledge and had continued to use technology partly to teach difficult concepts rather than an entire course. She appears to have been dissuaded by the inadequacy of technical infrastructure. In her estimation, even Blackboard had no sufficient space to upload large videos. Besides, the document camera, which all staff members in the department in question received a few months after the start of the lockdowns, was not available to all university lecturers. This validates the view that institutions have a responsibility to embed pedagogical affordances in their online teaching infrastructure (Dlamini & Ndzinisa, 2020).

Lecturer training

Participants, as literature confirms, raised the problem of training in online teaching. Although most participants thought training was enough under the circumstances, Nomsa believed it was too basic and did not delve into different teaching strategies for different courses or modules with online tools. Moreover, there was no standard institutional guidance on 'software to use' and 'how to utilise [those] software' (Sarah), leaving everyone to self-search solutions. Literature confirms the necessity to train staff in ICT skills (Nyawo, 2021), ID related processes (Dlamini & Ndzinisa, 2020), and to help lecturers adapt their teaching strategies to an online context (Ulla & Perales, 2019).

Results show that specific lecturers take personal initiative to train themselves in online teaching when they feel inadequately prepared. However, this seems to be regulated by the individual history and inclination towards the use of technology to teach. Fascinated with online teaching, for example, Rachel decided to complete a course on teaching with technology to enhance her pedagogic practice. She had grown up in an environment that embedded a flexible disposition on her.

In the light of the objective, institutional and individual constraints and inherent abilities above, the actual practices of lecturers were explored.

ID for online teaching

Online teaching was 'still relatively a young thing' (Sarah). Thus, all the lecturers who had a reflective and flexible disposition were not completely successful in either design or delivery of courses online. 'Redesign [of] the material' by Sarah was done in the context of ERT due to the context in which it was taking place. Laura captures the design problem well:

> I think we've done a lot of replicating what we did venue based; we have just done it in an online environment – and we haven't necessarily adapted it for an online environment. So, we still teach them, and then we have tutorial, and then they have to hand it in. We have just done it all electronically instead of physically.

Under normal institutional conditions, it takes a year and a half to design and deliver courses online (Hodges et al., 2020). However, the institution in question had not yet engaged 'thoroughly with what it means to have an online course' (Laura). That is why Sarah, projecting the future of online teaching, talked of the need for research on designing material for online teaching, in ways that increase student engagement and interaction. The implication is that left only to the whims of lecturers, design and delivery will continue to take on a fragmented and incremental evolution. This is in line with the never radical but small changes in the lecturer habitus, especially with the university now reverting to only 30% online and 70% face-to-face teaching in 2023 onwards, as opposed to fully or largely online teaching.

Participants reported somewhat significant changes in assessment approaches to avert cheating (Chloe & Sarah). These included continuous assessment, increasing the number of assessments and making them knowledge-application based. Sarah thought this change accounted for low pass rates in her course. However, there were concerns about the integrity of the assessments, a view shared by Cutri et al. (2020). Despite efforts to quell it, participants all agreed that cheating still continued because the university did not have sufficient infrastructure to invigilate assessments at the time of data gathering. The possibility that it may not even be a registered student who is writing the assessment left Nomsa feeling unsure about accepting online teaching. Even final assessment results could not be deemed sufficient evidence of learning because of the possibility of cheating by students (Maqableh, Alzyoud, & Zraquo, 2022).

Online pedagogic practices

Results show that the institution was not ready to offer online teaching (also see Mashau & Nyawo, 2021; Czerniewicz 2020). Consequently, lecturers had to move 'out of [comfort spaces' (Liziwe) and 'embrace the technologies that… were there and that people were slow to adopt' (Laura). Embracing new practices is possible concretely within the constraints of the habitus of lecturers. In relation to practice, Bourdieu does not think of 'the degree to which one can abandon oneself to automatisms of practical sense' in a rigid way. Instead, he foregrounds 'situation…, area of activity, and position occupied in social space' (Bourdieu, 2000: 163). Practices of the lecturers discussed below confirm this theorisation.

Trial and error

Through trial and error, participants explored different pedagogic aspects of technological tools – integration of videos in the delivery, use of PowerPoint slides with voiceovers, and implementation of more application-based assessments. They developed their own video lectures at first, changed their delivery approaches on the basis of student comments and topics at hand (such as theoretical, calculation-based topics), and students could request a slide presentation on a document camera video presentation (Liziwe). All these new practices came about through a challenging transition and reflect a reflective, flexible disposition on the part of lecturers in question.

In her trial and error, Sarah started by making two hours long lectures and talked too fast during lectures because she was used to not doing the 'talking while writing' on the board, in order to slow her pace down to 'help students… keep up'. After reflectively discovering these pedagogic dynamics, and through her informal chat with her students, she started breaking topics into sub-topics, delivering them in less time, and regulating her delivery pace. Moreover, she would pre-record short videos for students to independently go through and interact with before doing 'live work example' five days later.

Sarah, an 'old school lecturer' who 'likes chalk and talk', was uncomfortable at first because she was 'not a fan' of technology and avoided a computer if she could. But over time, she became comfortable because she had 'done it so often'. She was also scared of making mistakes in recorded lectures, which she thought could not be corrected once put out there for the 'world to see it'. The result confirms the link between repeating similar actions and the possibility of successful transition over the period in which the habitus is itself undergoing transformation and immersion.

But this link also shows that the duration of repetition of practices should be enough to avert the risk of reverting to 'old school' pedagogies for the likes of Sarah. For example, all lecturers interviewed did not favour a completely online teaching approach (see also Pomerantz & Brooks, 2017) for any number of reasons. Sarah started having 'supplemental contact classes' when lockdown rules were relaxed. She was not satisfied with the level of student interaction, not even with the outcome of break-away groups in the Blackboard platform. Student interaction and concentration is inadequate in an online platform (Ulla & Parales, 2021) but with effective use of online tools and creative pedagogies, this can be overcome.

Student feedback

All participants reported that student feedback provided during online teaching did not easily facilitate effective teaching and learning. It was 'difficult… to replicate in the online environment' (Nomsa). There was no 'instant lopper feedback' (Liziwe). Instant feedback helps lecturers instantly adjust their pedagogic processes to the demands of the moment (Liu & Long, 2014), without which some various pedagogic dimensions attached to it get lost. Liziwe captured what other participants shared thus:

> You can never replace the magic that happens in the physical venue. There is an instant lopper feedback that happens. I know when the students have missed the concept. I know if they are confused. I can see… there is just a… how do you say it… an environment that is available to us in the physical environment… that is difficult to replicate in the online environment.

A physical classroom appears to be more than a mere site of practice for agents. It is also a field in which multiple pedagogic possibilities inhabit and are found and intuitively exploited to facilitate teaching and learning. But it is evident that they are not easy to articulate in words. Participants call them with words such as energy, magic, light bulb and the like, so that the alternative (virtual, online) space lacks the mystery of the physical classroom. The inability to observe feedback and adjust to feedback in real time begged the question; how did lecturers adapt their pedagogic strategies to gain feedback from students?

Replicative, adjustive pedagogic practices

Since individuals have a creative and malleable habitus (Bourdieu, 2000), participants were asked how they adapted in the online classroom the elements they considered important to facilitate teaching and learning. They reported that they used polls, chat box, quizzes, prompted thumbs-up, and other emoticons. Thumbs-ups were prompted from students to indicate that they understood the content of lectures (Jane) or thumbs-down to indicate the opposite (Chloe). Polls were used to find out who was keeping up or left behind during lectures, to gauge response rates and the rate of correct answers. Emoticons were used to communicate feelings and at times were intentionally prompted by Jane to estimate whether students were keeping up.

There were mixed reactions about the use of chat box. Rachel believed that students were honest in answering her polls. Sarah said that some students sometimes consulted her after online lectures and admitted to having claimed to hear her in the chat box because 'they don't want [their answers] recorded that they don't know what's going on.'

Without being certain, this may be due to differences in class size and levels of study. It may also be that students in the first year (in Rachel's case) feel uncomfortable to admit this as continuing students do, and that the latter students do admit because they exercise their agency in ways, they feel favourable to their learning. The chat box tool was also used to gauge how many students were actively involved during class time (Lunathi). Rachel used them to allow students to engage with her and between and amongst themselves. These new practices reveal that participants adapted new ways of gaining feedback. The emerging question related to the navigation of teaching in the absence of the physical body and implicated theorising the unconscious, communicative body as an entity with pedagogic consequences.

Physical invisibility and pedagogic consequences

During lockdowns, lecturers were mostly speaking to blank screens, leading to the 'loss of human touch' (Laura). This physical invisibility meant that the environment available to assess student personalities and demeanours made it hard to adapt relevant pedagogic approaches during teaching. For example, in physical lectures, lecturers could easily detect students suffering from 'social issues… which they cannot deal with' (Lunathi & Nomsa). However, virtual platforms also provided aspects that affirm humanising pedagogy (Nomsa, Lunathi, Liziwe) – lecturers could have constant chats with students via social media, potentially making room for those shy to talk face-to-face with lecturers during and after lectures. Furthermore, there was a loss of human relations which usually evolves in the physical classroom.

Physical classrooms are critical for developing understanding of lecturer demeanour and the latter's pedagogic dimension. In this context, Lunathi summarised the difference between face-to-face and online teaching:

> When you are in a [physical] class environment, because then the students are exposed to you, they know you; they have studied you… So, they know they will know how to approach you, they will know how to kind of interact with you, because they have that experience. They have seen your reaction; they've seen your attitude. They've seen you and they understand even the language that you talk in class. But in online environment, students don't know that. They don't know you; they are like new students to you. So, even if you're joking or you're being hard, but not hard in a bad way, they can't distinguish because they don't know you.

Online space makes misunderstanding and confusion likely in connection to the above. An intended joke with pedagogic intent may be perceived negatively by a student who is not otherwise attuned to a lecturer's demeanour to which Lunathi refers. Thus, bodily visibility appears to create an entry point into the practical knowledge of the mundane but important pedagogic behaviours of a lecturer.

Students learn by their own unconscious effort to 'know' and 'understand' the 'attitude' and 'language' of lecturers through the latter's bodily posture. This is incorporated in and consistent with the language they 'talk in class' or its communicative nuances as implied by Lunathi. It includes its cultural and professional pedagogic value (respect for time, participation, discipline, and the like) and its nuanced strategies (jokes, sarcasm understood as such by students) to elicit student engagement and learning. Since students and lecturers have disproportionate capitals due to their different hierarchical positions in the field, the physical classroom seems to mediate the disproportion in quite useful ways.

The second finding relates to the participants' lack of access to non-verbal cues (bodily gestures) that serve as instant feedback and communicative means. Non-verbal cues, which also communicate student emotions are most frequently used and are crucial to communicating the level of understanding during lectures (Sathik & Jonathan, 2013). Lecturers use students' physical bodies to keep record of who is present. Moreover, they use them to adapt teaching strategies (Maqableh et al., 2022). A lecturer's bodily movement, such as walking around to see students work during 'class activities' (Nomsa), summoning up their attention, and sizing up their expressions through his/her own expressions – which also helps lecturers see 'students at the back [of the classroom] that normally sneak' (Liziwe) –communicates not just lecturer physical presence in class but its meaning to students, that 'there is nowhere to hide' because Liziwe will possibly 'walk right next to me [a student]' to elicit participation.

Chloe even uses the colour of the clothes students are wearing during lectures and clusters them accordingly to elicit participation in her class on particular days. Thus, physical classrooms carry pedagogic possibilities that are discovered by lecturers either intuitively and or reflectively. Through the body and its expressions, student cognition can be instantly evaluated. Lecturers are able to see learning in real time – the 'light bulb' (Jane), 'the magic that happens' (Liziwe), the indescribable 'energy' that drives interaction in class (Sarah) and the extent of attentiveness of students in class.

Liziwe, like all of the participants, thought there was lack of student participation and 'did not know what to do' about it because her pre-lockdown strategies or incentives (giving away chocolates, sweets, etc.) used to elicit student participation could not be practicable. Sarah said that making students engage required serious effort, even in a physical classroom environment, consistent with Dhawan's (2020) assertion that eliciting student engagement is a challenge. On the contrary, Rachel, who teaches a large class of about 300 students, felt that student engagement 'exceeded all [her] expectations', perhaps because they 'feel safer behind the device'.

Sarah reported a 'loss of peer-to-peer engagement', where students were deprived of the deep learning that occurs while 'debating a point' in a face-to-face space. Rachel tried to use discussion groups in this regard, without success. This could be due to a lack of student historical culture of engagement prior to and once in university. Engagement also arises from embedding student independence and discipline, which all participants agreed was wanting and yet critical for effective online teaching and learning. In hindsight, Rachel thought that in future, marks could be used to incentivise students to engage each other in the discussion board. Her ideas seemed to form as a result of accumulating strategies in practice rather than merely in contemplation. This confirms the vitality of both practice and reflecting about it whilst in it and after it. As they had 'to make a way', lecturers had to find ways to adapt to the situation of bodily absence via, *inter alia*, verbal prompts to elicit some kind of participation via emoticons.

Prompted bodily behaviour

Effectively, bodily hexis, '… the site of incorporated history' (Thompson, 1991: 13; see also Bourdieu, 1984: 437), engrossed in the foregoing discussion, manifests behaviour that operates below consciousness. This warrants problematising the distinction between the **natural**, unprompted student bodily expression and the calling to conscious behaviour a representation of original, now unseen, bodily expression of students which Jane talks about in her adjustive pedagogic practice. The problem is that an original bodily (facial) expression is not called forth by the mind per se because it is automatic (Maqableh et al., 2022). Nor is it therefore recallable in its authentic, original form because it has already passed when prompted by a lecturer.

There are important implications if a bodily expression is theoretically recallable in its authentic sense: students who have a low opinion of themselves, arising from their low cultural capital embedded as part of their social and personal historical trajectory, may not use emoticons or words reflecting confusion or lack of understanding at the prompting of a lecturer, if they deem that to further lower their sense of self and confidence, perhaps because in a normal classroom situation, some students are already reluctant to express themselves (Abdulrahman, Bingol & Kara, 2022), as in an online class (Chloe), leaving a lecturer unsure about their extent of learning. Thus, Jane potentially receives inauthentic feedback, and she has no other mechanism to see the 'light bulb' in its original form as a confirmation of real learning.

CONCLUSION

The study reveals an evolving shift of lecturer habitus about how and where learning takes place. However, practices found do not yet reflect highly evolved online pedagogic approaches. To this extent, lecturer practices reflect a habitus with a combination of creative coping during lockdowns and exploratory practices post the lockdowns. The external demand by SAICA for students with digital acumen seems to be playing an additional role in shaping this exploratory habitus into the future. No fundamental, conscious change has taken place in ID in its relation to online teaching.

The institution under study is reverting to largely face-to-face teaching. This has one of the two opposite implications: 1) the possibility of neglecting the online dimension, or 2) allowing lecturers an opportunity, without pressure, to explore inherent pedagogic affordances in technological tools. The reversion also makes institutional training to facilitate the possibility of the latter implication necessary. The results reaffirm the view that training must seek to transform the lecturer habitus in such a way that it eases integration of technological, online tools into pedagogic processes (Tarling & Ng'ambi, 2016).

The focus of the training should be related to the way material is designed and course material split, written, prepared for delivery, and finally delivered (Feldman & Fataar, 2017), followed by reflection in the online pedagogic processes in order to make possible the redesign of the material and pedagogy (Goodyear, 2015) as informed by practice. It must be explorative in nature and be continuous, if online pedagogic practices are to concretise into the optimal use of inherent online pedagogic resources. The training must move beyond basics such as accessing, loading, creating or accessing links to addressing deeper issues raised by Nomsa.

The study shows that lecturers currently rely on various pedagogic tools to elicit participation, and deal with the absence of non-verbal cues. There is no certainty that these pedagogical strategies achieve the objective effectively. More specifically, it has been shown that student bodily invisibility during online classes presents problems for effecting teaching and authenticating lecturer-prompted responses from students. Further research that critically evaluates, specifically, the lecturer-student use of emoticons as an adaptive means to online teaching may shed more light on the extent of the success of these pedagogic devices.

Effectively, this study hints at the need to investigate whether pedagogic devices are embeddable in a way that is replicable of the physical environment in ways that evolve practices reflecting a new way of re-establishing the human touch that is somewhat lost, including new ways of seeing or experiencing the 'lightbulb' otherwise forgone in the online classroom.

REFERENCES

Abdulrahman, S.A., Bingol, M.A. & Kara, S. (2022) Body Language in Education and Effective Recommendations to Pre-Service Teachers in Classroom Management. *International Journal of Social Sciences and Educational Studies* 9(1) pp.298-307, https://10.23918/ijsses.v9i1p298

Bagarukayo, E. & Kalema, B. (2015) Evaluation of e-learning usage in South African universities: A critical review. *International Journal of Education and Development using Information and Communication Technology* 11(2) pp.168-183, https://files.eric.ed.gov./fulltext/EJ1074146.pdf

Blume, C. (2020) German Teachers' Digital Habitus and Their Pandemic Pedagogy. *Postdigital Science and Education* 2 pp.879-905, https://doi.org/10.1007/s42438-020-00174-9

Bozkurt, A. & Sharma, R.C. (2020) Emergency remote teaching in a time of global crisis due to Coronavirus pandemic. *Asian Journal of Distance Education* 15(1) https://doi.org/10.5281/zenodo.377808

Branch, R.M. & Dousay, T.A. (2015) *Survey of instructional design models. Association for education communities*. Association for Educational Communications and Technology (AECT), https://aect.org/docs/surveyofinstructionaldesignmodels.?pdf=surveryofmodelsofinstructionaldesignmodels

Braun, V & Clarke, V (2021) One size fits all? What counts as quality practice in (reflexive) thematic analysis? *Qualitative Research in Psychology* 18(3) pp.328-352, https://10.1080/14780887.2020.1769238

Braun, V. & Clarke, V. (2012) Thematic analysis. In H. Cooper, P.M. Camic, D.L. Long, A.T. Panter, D. Rindskopf & K.J. Sher (Eds.) *APA handbook of research methods in psychology, Vol. 2: Research designs: Quantitative, qualitative, neuropsychological, and biological*. Washington, DC: American Psychological Association 13 pp.57-71 (Accessed 29 July 2023).

Cutri, R.M., Mena, J. & Whiting, E.F. (2020) Faculty readiness for online crisis teaching: transitioning to online teaching during the COVID-19 pandemic. *European Journal of Teacher Education* 43(4) pp.523-541, http://doi.org./10.1080/02619768.2020.1815702

Czerniewicz, L. (2020) *What we learn from "going online" during university shutdowns*. PhilOnEdTech, https://er.educause.edu/articles/2020/03/the-difference-between-emergency-remote-teaching-and-online-learning#fn4 (Accessed 20 July 2021).

Feldman, J. & Fataar, A. (2017) Embodying pedagogical habitus change: A narrative-based account of a teacher's pedagogical change within a professional learning community. *Journal of Education* 70 pp.73-88, http://joe.ukzn.ac.za

Goodyear, P. (2015) Teaching as design. *Herdsa Review of Higher Education* 2(2) pp.27-50, https://doi.org/10.1111/hea.12037_26

Hew K.F., Jia, C., Gonda, D.E., & Bai, S. (2020) Transitioning to the "new normal" of learning in unpredictable times: pedagogical practices and learning performance in fully online flipped classrooms. *International Journal of Education Technology in Higher Education* 17(57) pp.1-22, https://doi.org/10.1186/s41239-020-00234-x

Hodges C., Moore S., Lockee B., Trust T. & Bond, A. (2020) *The difference between emergency remote teaching and online learning*. *Educause Review*, https://er.educause.edu/articles/2020/3/the-diference-between-emergency-remote-teaching-and-online-learning (Accessed 04 August 2021).

Kreber, C. & Kanuka, H. (2006) The scholarship of teaching and learning and the online classroom. *Canadian Journal of University Continuing Education* 32(2) pp.109-131.

Liu C. & Long F. (2014) The discussion of traditional teaching and multimedia teaching approach in college English teaching. Paper presented at the *2014 International Conference on Management, Education and Social Science* (ICMESS 2014), https://doi.org/10.2991/icmess-14.2014.9

Maqableh, W., Alzyoud, F.W. & Zraqou, J. (2022) The use of facial expressions in measuring students' interaction with distance learning environments during the COVID-19 crisis. *Visual Informatics* pp.1-28, https://doi.org/10.1016/j.visinf.2022.10.001

Mardiana, H. (2020) Lecturers' Attitudes towards Online Teaching in the Learning Process. *Register Journal* 13(1) pp.77-98, https://doi.org/10.18326/rgt.v13i1.77-98

Mashau, P. & Nyawo, J.C. (2021) The use of an online learning platform: a step towards e-learning. *South African Journal of Higher Education* 35(2) pp.123-143, https://dx.doi.org/10.20853/35-2-3985

Mayer, P. & Girwidz, R. (2019) Physics teachers' acceptance of multimedia applications – Adaptation of the technology acceptance model to investigate the influence of TPACK on physics teachers' acceptance behavior of multimedia applications. *Frontiers in Education* 4(73), https://doi.org/10.3389/feduc.2019.00073

Ng'ambi, D. & Bozalek, V. (2016) Chapter 12: Learning with Technologies in resource-constrained environments. In N. Rushby & D.W. Surry (Eds.) *The Wiley Handbook of Learning Technology*. Wiley Blackwell, pp.200-220.

Nyawo, J.C. (2021) Comparison of Undergraduate Students' Perception of Tutorials Before and During the COVID-19: A Case of the University of Kwazulu-Natal in the Discipline of Public Governance. *International Journal of Higher Education* 10(2) pp.217-228, http://ijhe.sciedupress.com

O'Flaherty J. & Phillips, C. (2015) The use of flipped classrooms in higher education: a scoping review. *Internet and Higher Education* 25 pp.85-95, https://doi:10.1016/j.iheduc.2015.02.002

Rapanta, C., Botturi, L., Goodyear, P., Guàrdia, 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 pp.923-945, https://doi.org/10.1007/s42438-020-00155-y

Ruslin, Mashuri, S., Rasak, M.S.A., Alhabsyi, F. & Syam, H. (2022) Semi-structured Interview: A Methodological Reflection on the Development of a Qualitative Research Instrument in Educational

Studies. *Journal of Research & Method in Education* 12(1) pp.22-29, https://doi.10.9790/7388-1201052229

Sathik, M. & Jonathan, S.G. (2013) Effect of facial expressions on student's comprehension recognition in virtual educational environments. *Springer Plus* 2 pp.455, https://doi.org/10.1186/2193-1801-2-455

Tarling, I. & Ng'ambi, D. (2016) Teachers pedagogical change framework: a diagnostic tool for changing teachers' uses of emerging technologies. *Teaching in Higher Education* 15 pp.531-542. *British Journal of Educational Technology* 47(3) pp.554-572, https://doi:10.1111/bjet.12454

Ulla, M.B. & Perales, W.F. (2021) Emergency Remote Teaching During COVID-19: The Role of Teachers' Online Community of Practice (CoP) in Times of Crisis. *Journal of Interactive Media in Education* 9(1) pp.1-11, https://doi.org/10.5334/jime.617

Van de Heyde, V. & Siebrits, A. (2019) The ecosystem of e-learning model for higher education. *South African Journal of Science* 115(5/6) pp.1-6, http://dx.doi.org/10.17159/sajs.2019/5808

Varpio L., Ajjawi R., Monrouxe L.V., O'Brien B.C. & Rees C.E. (2017) Shedding the cobra effect: problematizing thematic emergence, triangulation, saturation and member checking. *Medical Education*. 51(1) pp.40-50, https://doi.org/10.1111/medu.13124

An analysis of online learning and teaching at the Department of Electronic Engineering at a university of technology during the coronavirus pandemic in South Africa[3]

Shaveen Maharaj, Durban University of Technology, South Africa

ABSTRACT

The Department of Electronic Engineering at a South African University of Technology is currently conducting a research study to investigate the challenges associated with online teaching during the COVID-19 epidemic. Specifically, the study focuses on the perspective of educators in this context. In response to the outbreak, governments worldwide implemented nationwide lockdowns to curb the spread of the virus, leading educational institutions, including universities, to cease in-person instruction. This sudden shift disrupted the educational system, necessitating a rapid transition from traditional face-to-face teaching to online methods to fulfill the curriculum requirements. As faculty members encountered various difficulties in adapting to online teaching pedagogy, the research study concentrates on them as the primary participants. The research study provides recommendations that offer valuable guidance for improving the effectiveness of online teaching practices which may be applied outside of the pandemic to most online teaching pedagogies.

Keywords: COVID-19 impact, higher education institutions, online teaching, Learning Management System (LMS)

INTRODUCTION

Research Background

The COVID-19 virus, initially identified in Wuhan, China, in December 2019, quickly spread worldwide, affecting countries globally (Pokhrel & Chhetri, 2021). The ensuing pandemic led to widespread economic shutdowns and disruptions in education systems, as nations followed the World Health Organization's precautionary measures. To mitigate the spread of the virus and flatten the curve, strict lockdown measures were implemented, resulting in the closure of educational institutions and the suspension of in-person learning (Sintema, 2020). This disruption highlighted the challenges faced by developing nations and exacerbated existing societal inequalities, as e-learning became the predominant mode of education. Higher education institutions rapidly transitioned to online teaching and learning, utilizing new technologies and platforms to ensure continuity in the academic curriculum for 2020. However, this shift presented significant challenges for both educators and students, who grappled with the limitations of remote work without adequate infrastructure (Abdulkareem & Eidan,

[3] Date of Submission: 30 January 2023

Date of Review Outcome: 12 June 2023

Date of Acceptance: 4 September 2023

2020).

Problem statement and rationale

The COVID-19 pandemic caused significant disruptions in the higher education sector, leading to university closures and a sudden transition from face-to-face teaching to online instruction (Abdulkareem & Eidan, 2020). The Department of Electronic Engineering at a University of Technology in South Africa experienced this abrupt shift, which brought about substantial challenges. This research study aims to shed light on the prominent difficulties faced within the academic programme, focusing on the perspective of educators. The following topics are investigated in this study (Bania & Banerjee, 2020):

1. Assessment integrity during online testing: Students employ various techniques to cheat during online assessments, raising concerns about the reliability of the assessment process.
2. Educators' mental health and well-being during the pandemic: The study examines the impact of the pandemic on educators' emotional and psychological well-being.
3. Lack of formal pedagogies for effective remote and online teaching in the electronic engineering programme: The research addresses the absence of established strategies to enhance the quality of remote instruction.
4. Intermediate electricity disruptions from Eskom, South Africa's energy supplier: Frequent 'load shedding' by Eskom hampers consistent access to online platforms, leading to disruptions in online lessons, assessments, and meetings. This results in missed deadlines, assessments, and lost information due to network crashes.
5. Lack of leadership during the COVID-19 pandemic: The study explores the challenges arising from a lack of effective leadership in managing the crisis within the education system.

By investigating these areas, the research aims to provide valuable insights into the challenges faced by educators in the electronic engineering programme during the transition to online teaching and learning.

Aim and objectives

This research study aims to generate recommendations to ensure the development of an online teaching and learning strategy for the Department of Electronic Engineering at the Durban University of Technology in South Africa.

These recommendations have been constructed based on a SWOT analysis of the performance of the Department of Electronic Engineering during the current COVID-19 pandemic. The main aim of the research study is to uncover the impact of online teaching and learning during the COVID-19 pandemic.

The key objectives of this research project are:

- To identify the major challenges in the Department of Electronic Engineering from the educator's perspective.
- To execute a SWOT analysis of the current state of online teaching and learning in the Department of Electronic Engineering.
- To provide recommendations to the Department of Electronic Engineering that will help overcome possible challenges to the programme.

LITERATURE REVIEW

Online teaching

Online teaching has become known as a contradistinctive aim to traditional face-to-face teaching methods conducted in a classroom environment. Online education is commonly described as an educational experience utilizing numerous electronic or smart devices such as computers or laptops, smartphones, and tablets. These electronic devices are usually internet compatible and enable the platform to be student-centered providing flexibility to the students (Zalat, Hamed & Bolbol, 2021). Online teaching offers both educators and students the opportunity to be independent of timetables or classrooms with the use of web-based software packages so they can participate in their space in their time. Each institution adopts a learning management system (LMS) or virtual learning environment (VLE) that would allow educators and students to access learning materials via the Internet. Some of the common software tools used for LMS are Moodle and Blackboard (Nortvig, Petersen & Balle, 2018).

Challenges of online teaching during the pandemic

The direct impact of the global COVID-19 pandemic on the higher education sectors has been devastating and many educators are wondering what the future holds for online teaching and will the current situation transform how higher education institutions' function going forward (He & Xiao, 2020). The advantages and disadvantages of the current shift to online teaching must be studied carefully to ensure corrective decisions are made for the continuation of quality education (Calonge et al., 2022).

During the COVID-19 pandemic, educators had to adapt rapidly to remote teaching in the face of universities closing their campuses abruptly, as a result, educators found themselves teaching in unfamiliar circumstances. Educators needed to ensure they created an environment that was conducive to student learning while meeting the standards of the higher institutions and the expectations of the students (Carrillo & Flores, 2020). The sudden shift from traditional teaching methods to online teaching was unexpected and more significantly, it was imposed onto numerous educators and higher education institutions. This brought about numerous challenges and opportunities. Some of the underlying challenges identified from published papers during the pandemic are:

- Lack of proper online infrastructure
- Educators' mental health during remote teaching
- Lack of experience from educators
- Large information disparity
- The complication that comes with functioning from a home environment
- Lack of mentoring and support for both educators and students
- Lack of technological competencies displayed by educators (König et al., 2020).

Pedagogy and technology for online education during the COVID-19 pandemic

During the global pandemic, online teaching was utilized as the only viable option to continue with the educational system (Gherhes et al., 2021). When considering educational pedagogy during the COVID-19 pandemic, it must be emphasized the unusual circumstances that educators have been thrust into without having inadequate training and resources as well as insufficient guidance from department leaders to manage the situation (Hollweck & Doucet, 2020).

Numerous research studies have examined pedagogical strategies for online teaching in education. These studies have revealed that an effective online programme, based on constructivist philosophy, should be applicable, synergetic, and practical (Kim & Bonk, 2006). Educators in higher education institutions have expressed that online instructional strategies create a supportive and encouraging environment for student inquiry, expand students' knowledge of the subject matter, and foster enthusiastic and critical reflection on their growth and experiences.

An interesting finding from a pedagogical practice survey indicates that 40% of educators consider it highly important for the online environment to include interactive laboratory work, data analysis, and data simulation (Kim & Bonk, 2006). The absence of these activities can create a significant gap between desired and actual online instructional practices in the programme. Technology has played a crucial role in driving the development and growth of online education, with many higher education institutions, including universities, investing in educational software packages and tools. Over the past decade, the integration of blogs, wikis, and podcasts has become increasingly popular in online education, serving as effective teaching and learning aids (Kim & Bonk, 2006).

It is important to acknowledge that remote teaching during the pandemic was implemented as an emergency measure and cannot be directly compared to e-learning, home education, or regular online learning practices (Berry, Doucet & Owen, 2020). While these distance education methods provide valuable insights, their outcomes cannot be replicated in the context of a sudden closure of educational institutions, allowing little time for design thinking or reflection in establishing remote-based instructional programmes. The lack of clear guidelines from institutional management during the pandemic led to educators responding to vague or misinformation, resulting in frustration among educators, parents, and students (Hollweck & Doucet, 2020). It was unanimously agreed by all stakeholders that there was no clear vision for effective teaching during the pandemic (Hollweck & Doucet, 2020).

It is important to note that the pedagogical methods employed during the pandemic for remote online teaching were not as simple as converting face-to-face lessons into video conferences or PowerPoint presentations uploaded onto learning management systems (LMS) such as Blackboard or Moodle (Hollweck & Doucet, 2020). Instead, more robust, and innovative pedagogies were needed, including providing direct and meaningful instruction that encourages critical thinking, individualizing subject material, and employing competency-based approaches to curricular content. Additionally, students should be given guidance to pace themselves during well-instructed lessons and offered opportunities for self-reflection. Educators must provide continuous and meaningful feedback to students as an integral part of the learning experience. Furthermore, the mental health and well-being of both educators and students must be prioritized in remote pedagogies during the pandemic (Hollweck & Doucet, 2020). Within the global educational community, there have been calls to prioritize students' basic needs before fully focusing on academic learning (Hollweck & Doucet, 2020).

Mental health and well-being during the pandemic at higher education institutions

The World Health Organization (WHO) advised governments to curb the spread of the COVID-19 virus by introducing national lockdowns to restrict the movement of non-essential businesses and services (Pokhrel & Chhetri, 2021). This meant that higher education institutions across South Africa had to close their campuses and staff had to work remotely while students returned home. Higher educational staff found themselves in a situation that placed their mental health and well-being at risk by constraining them to their households while attempting to save the academic curriculum. Studies have shown that national lockdowns can have a negative impact on the continuity of the academic curriculum in higher education institutions, as well as the mental health and well-being of academic staff and students. The South African government enforced the national lockdown since the beginning of the COVID-19 pandemic, and as a result, it further intensified the mental health issues among the institutional staff in the country such as depression, anxiety, and stress (van Niekerk & van Gent, 2021).

The United Nations (UN) made a statement raising concerns about the state of people's mental health and psychological well-being (PWB) during the COVID-19 pandemic (van Niekerk & van Gent, 2021). It warned that mental health should not be taken lightly and has the potential to inflict high levels of stress and anxiety. Guidelines were provided on how to address the situation. The UN recognizes that during a pandemic people tend to develop fear, concern, and anxiety when trying to deal with a threatening situation and so need to safeguard their mental health and well-being throughout the COVID-19 pandemic. However, the UN suggests that a large outbreak in mental health associations must be anticipated, given the past and present mental health illnesses and distress. The high level of poverty and unemployment in South Africa presented a major challenge when dealing with mental health and well-being in a developing country (van Niekerk & van Gent, 2021).

Research findings indicate that in South Africa, there has been a significant rise in depression and anxiety among academic staff in higher education even before the onset of the pandemic. This surge in mental health issues can be attributed to various factors identified in the study. These factors include work-related stress, heightened workloads, the implementation of performance evaluation methods by senior management that are often unattainable, the competitive nature of publishing in academic journals, and the prevalence of part-time employment (van Niekerk & van Gent, 2021).

Moreover, the research highlights the further impact on academic staff when confronted with additional challenges because of the sudden shift to online teaching. These include: the lack of clear guidelines for remote work, limited social interaction with students, increased administrative responsibilities, and a notable lack of support from management. These findings underline the significant impact of these conditions on the well-being and mental health of academic staff in the higher education sector (van Niekerk & van Gent, 2021). Further findings suggested that institutional staff felt a 'sense of uncertainty and anxiety about what is going to happen' during the pandemic and this saw a shift in their mental health from work-related stress to anxiety as the major fear among staff at the institution. Thus, it can be concluded that educators' competence and skills to conduct online teaching under the current circumstances is the primary contributor to their increased anxiety levels. It is understood that educators faced the COVID-19 pandemic in three stages: stage 1: vagueness and uncertainty, being challenged with new work methods; stage 2: exhaustion, driven by novel experiences and concerns; and stage 3: re-opening, developing novel emotions of doubt between educators in the institution (van Niekerk & van Gent, 2021).

METHODOLOGY

Research philosophy and approach

The research philosophy for this study is pragmatism. Pragmatism is prefaced on the notion that research can avoid the philosophical debates about the nature of truth and reality while focusing rather on the 'practical understandings' of solid, real-world problems just as online teaching and learning challenges during the pandemic presented in this research study (Kelly & Cordeiro, 2020).

The research methodologies that are best suited for use in the pragmatic paradigm support the application of both qualitative and quantitative research methods according to their need. The research conducted within the pragmatic paradigm draws on methodologies from qualitative and quantitative methods. This provides the advantage of transitioning between qualitative data and quantitative data, which is frequently regarded as incompatible. This allows researchers the opportunity to investigate and seek valuable information to connect these two different types of data (Kivunja & Kuyini, 2017). Pragmatism has demonstrated how it can link induction with deduction, subjectivities, objectivity, context and generality, intersubjectivity, and transferability. The strength of qualitative research is its transferability. Hence, in pragmatism, the transferability of the research is supported by the range and the detail of the data presented from the link between the quantitative and qualitative approaches. The pragmatic approach would be utilized in the research to connect theory from the literature to the data collected. Pragmatism permits the prospective and possibility to work between qualitative data and quantitative data. Pragmatism presents researchers with the opportunity to seek out valuable points of association between quantitative and qualitative data in the study (Tran, 2017). The approach used will be deductive as existing knowledge and theories would look to be validated in the study.

The research employed mixed methods with both a qualitative and quantitative phenomenological inquiry into participants' experience during online teaching in the Department of Electronic Engineering during the COVID-19 pandemic. While quantitative and qualitative research approaches are considered different, they complement each other when applied together in a study (Ahmad, et al., 2019).

Research design and strategy

This research applied the survey strategy for the collection of data. A total population of 40 staff members from the Department of Electronic and Computer Engineering were invited to participate in this study. A total of 24 participants responded through a set of online questionnaires, resulting in a 60% response rate. The advantage of using the survey in the research allows for numerous methods to recruit participants, collect data, and apply different techniques of instrumentation. Another reason why the survey strategy was employed in this research is that it can utilize quantitative research strategies such as questionnaires with numbers and graphs as well as qualitative research strategies with open-ended questions to aid this research in gathering data for the SWOT analysis. Hence, the survey strategy is well-suited for our mixed-method research. The limitation of utilizing the survey method in this study was that participants were on vacation leave for the end of the semester and participants may have not been motivated to complete the survey resulting in a lower response rate (Ponto, 2015).

The primary data for the research was collected with the aid of a questionnaire to form both quantitative and qualitative data. The survey was well structured so that the primary data collected from the small cohort of participants was quantitative and qualitative (Hox & Boeije, 2005). Having both types of data means that the quantitative data can be processed by applying both graphs and statistical methods of analysis to determine the relationship between the variables of the study. Quantitative data were gathered from the survey using closed-ended questions. Qualitative data are used to enhance and strengthen the quality of the survey as well as expand or refine the quantitative findings. This was achieved by inputting open-ended questions in the survey (Kabir, 2016). The primary data were collected using a cross-sectional survey, where a time limit of 30 days was given to participants to complete and submit their responses.

ANALYSIS AND FINDINGS

Analysis of the average mean of the 5-Point Likert Scale Questionnaire

The Likert scale responses were given the 5-point options, 'agree', 'somewhat agree', 'neutral', 'somewhat disagree,' and 'disagree'. Each one of these responses was assigned weightings as follows: Agree (5), somewhat agree (4), neutral (3), somewhat disagree (2), and disagree (1).

From Table 1, the 11 survey questions are represented by their corresponding average mean value and the most frequent response. The average mean provides a concise summary of the central tendency of the Likert scale responses. By focusing solely on the average mean, a clear and concise overview of the participant's overall level of agreement or disagreement with the statements is presented.

Table 1:
The Likert Scale Range Findings

Question	Average Mean	Scale output
1. The transition from face-to-face teaching and learning to online teaching and learning has been smooth and effective during the pandemic.	1,33	Disagree
2. Educators were given the appropriate technical support to conduct online teaching and learning during the pandemic.	2,42	Somewhat Disagree
3. Students are performing better on their online assessments than during face-to-face assessments because they are cheating.	4,83	Agree
4. Online teaching and learning have been negatively impacted by load shedding in the country.	4,83	Agree
5. Online teaching and learning have been negatively impacted by students' data and network issues.	4,42	Agree
6. The Department of Electronic Engineering educators are adequately skilled and trained in online pedagogy.	2,17	Somewhat Disagree
7. Online simulation programs such as MATLAB and Multisim are adequate to replace traditional practicals.	1,5	Disagree
8. Educators were given adequate guidelines and policies for remote pedagogy during the pandemic.	2,25	Somewhat Disagree
9. The learning management system (LMS) Moodle is effective for online teaching and learning meeting the department's requirements.	2,42	Somewhat Disagree
10. Educators' mental health and well-being have been negatively impacted by online teaching and learning during the pandemic.	4,75	Agree
11. The qualification offered in the Department of Electronic Engineering can be effectively conducted using online teaching and learning tools only.	1,92	Somewhat Disagree

Analysis of the quantitative data

The responses from the survey questionnaire given to the staff members in the Department of Electronic Engineering were converted from weightings into percentage form and displayed graphically.

Analysis of Question 1:

The Likert scale response to Question 1, evaluates the transition from face-to-face teaching and learning to online teaching and learning during the pandemic, indicates a lack of satisfaction among the participants. The responses 'somewhat disagree' and 'disagree' collectively account for 100% of the participants surveyed.

Implications:
The percentage breakdown of responses in Figure 1 below shows that a significant majority (66.7%) of participants outright disagreed with the effectiveness and smoothness of the transition, while a smaller portion (33.3%) expressed a more moderate level of disagreement by choosing 'somewhat disagree'.

The high percentage of participants who disagreed suggests that the transition from face-to-face to online teaching and learning during the pandemic did not meet their expectations or requirements.

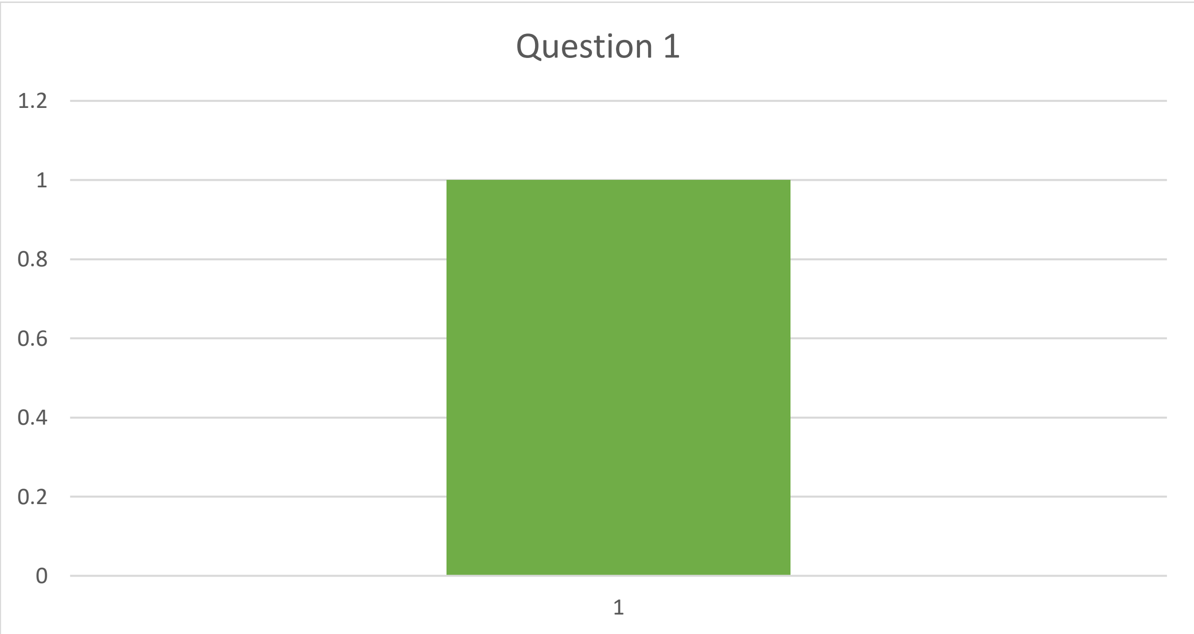
Challenges Faced: The responses indicate that a significant number of participants encountered difficulties during the transition, which might have negatively impacted their teaching effectiveness.

Potential Room for Improvement: The results show that there is a need to identify and address the specific issues and challenges faced by participants during the transition process to enhance the effectiveness of online teaching and learning.

Support and Training: Participants may have felt unprepared to adapt to online teaching methods. Providing adequate support, training, and resources to educators and learners could improve their experience during online instruction.

Pedagogical Adaptation: Understanding the reasons for the dissatisfaction can help identify areas that require pedagogical adjustments to ensure a more seamless transition between face-to-face and online teaching methods.

Figure 1:
Graphical representation of Question 1



Analysis of Question 2:
The Likert scale response to Question 2, which assesses whether educators received appropriate technical support for online teaching and learning during the pandemic, reveals a mixed and concerning sentiment among the participants. The responses in Figure 2 are distributed across all possible options, with 16.7% agreeing, 16.7% somewhat agreeing, 25% somewhat disagreeing, and 41.7% disagreeing.

Implications:
The fact that 41.7% of participants outright disagreed with receiving appropriate technical support suggests that a significant portion of educators felt inadequately supported during the transition to online teaching.

Mixed Perceptions: The distribution of responses across all options indicates a lack of consensus among participants, with some educators feeling supported to some extent while others did not.

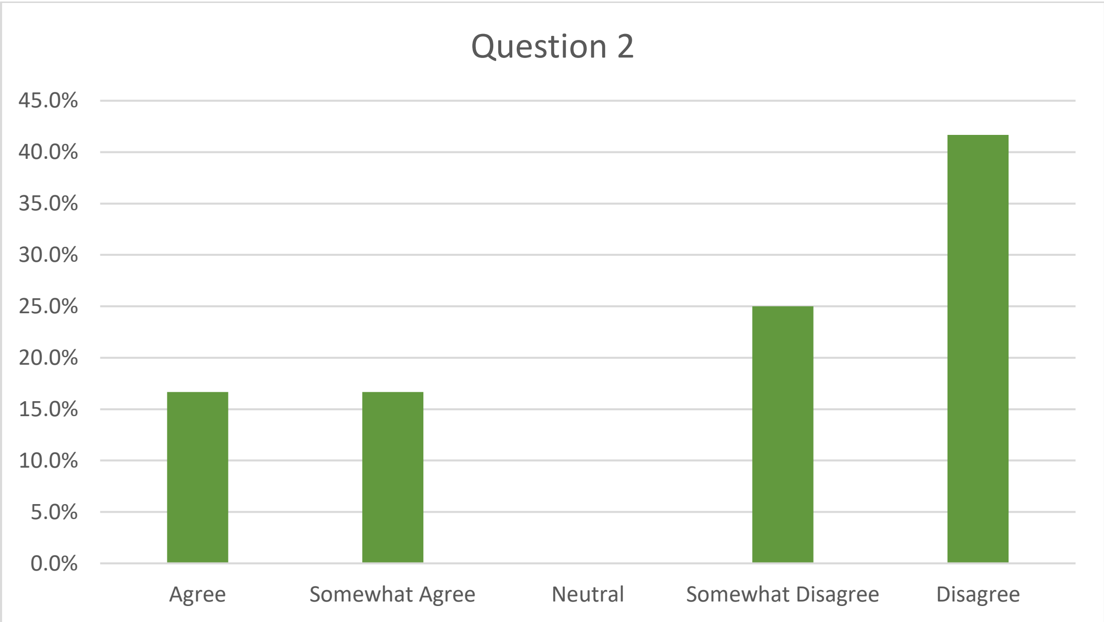
Challenges in Implementation: The relatively high percentage of respondents who somewhat disagreed (25%) and disagreed (41.7%) may indicate that educators faced challenges in implementing online teaching methods due to a lack of technical support.

Importance of Addressing Concerns: The responses indicate that a considerable number of educators did not receive the necessary technical assistance, emphasizing the need to address their concerns to improve the overall effectiveness of online teaching and learning.

Impact on Educator Performance: Inadequate technical support might have hindered educators' ability to conduct online classes effectively, impacting the quality of education and student engagement.

Figure 2:

Graphical representation of Question 2



Analysis of Question 3:
The Likert scale response to Question 3, addresses whether students are performing better on their online assessments due to cheating, reveals a concerning sentiment among the participants. Figure 3 below shows the vast majority (83.3%) agreed with the statement, and a smaller proportion (16.7%) somewhat agreed.

Implications:
The overwhelming agreement (83.3%) suggests that a significant number of participants believe that students are indeed performing better on online assessments due to cheating.

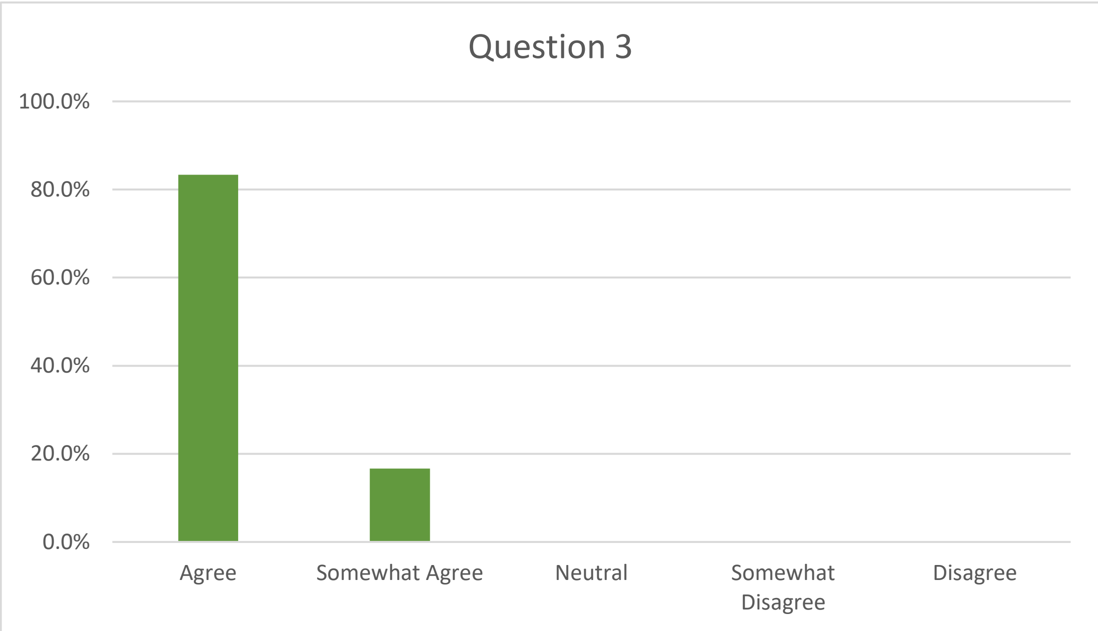
Academic Integrity Concerns: The high agreement percentage raises serious concerns about academic integrity and the validity of online assessments.

Assessment Security: The perception of widespread cheating on online assessments indicates potential vulnerabilities in the assessment security measures, requiring attention and improvement.

Impact on Student Evaluation: If a large portion of participants believe that cheating is rampant, it may influence how students are evaluated and undermine confidence in their academic achievements.

Need for Investigation: The response highlights the need for a thorough investigation into the validity of online assessments and the factors contributing to the perceived increase in cheating.

Figure 3:
Graphical representation of Question 3



Analysis of Question 4:
The Likert scale response to Question 4, examines the impact of load shedding on online teaching and learning, reveals a significant and concerning sentiment among the participants. Figure 4 below shows a vast majority (83.3%) agreed with the statement, and a smaller proportion (16.7%) somewhat agreed.

Implications:
Severe Impact of Load Shedding: The high agreement percentage (83.3%) indicates that load shedding has had a substantial negative impact on online teaching and learning in the country.

Disruptions in Teaching and Learning: Load shedding can disrupt online classes, causing power outages, and connectivity issues, and hindering the seamless delivery of educational content.

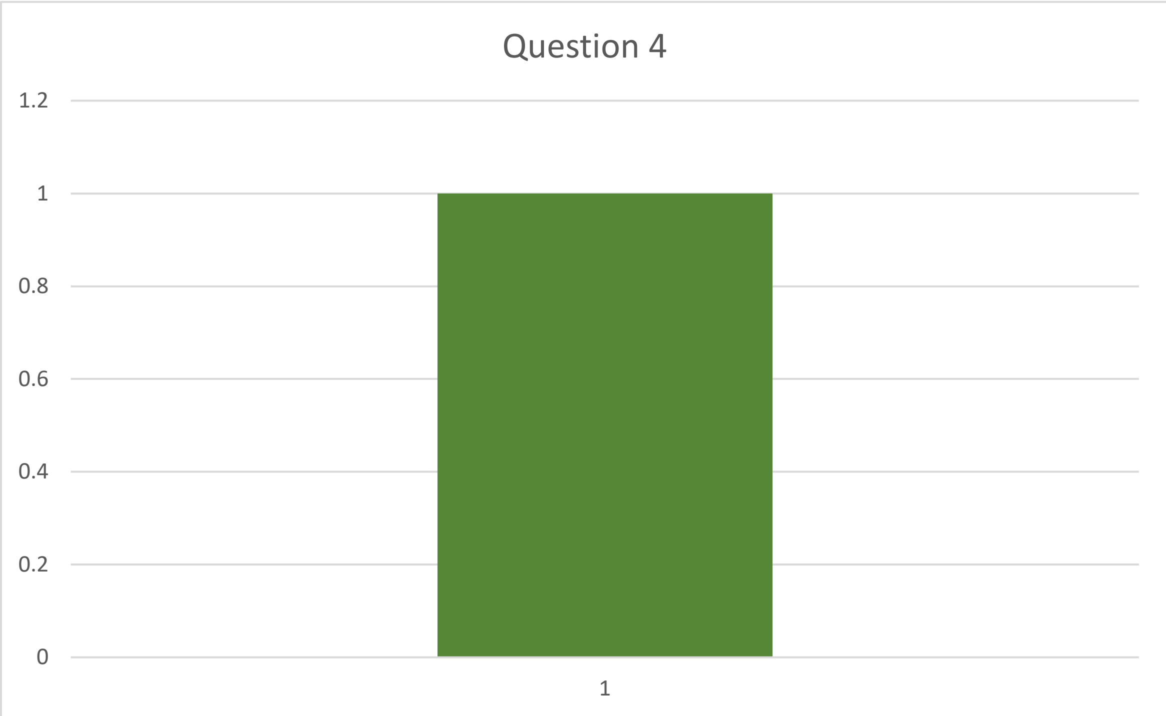
Technological Challenges: The response suggests that the country's load-shedding situation poses significant challenges in providing consistent and reliable access to online resources and platforms.

Inequitable Learning Experience: Load shedding may lead to inequitable learning experiences, as some students might have more reliable access to electricity and the internet than others.

Stress and Frustration: Frequent disruptions due to load shedding can lead to increased stress and

frustration among educators and students, affecting their engagement and performance.
Need for Mitigation Strategies: The high agreement percentage highlights the urgency of implementing mitigation strategies to address the impact of load shedding on online teaching and learning.

Figure 4:
Graphical representation of Question 4



Analysis of Question 5
The Likert scale response to Question 5, explores the impact of students' data and network issues on online teaching, indicates a significant concern among the participants. Figure 5 below shows the majority (66.7%) agreed with the statement, a substantial portion (25%) somewhat agreed, and a smaller percentage (8.3%) disagreed.

Implications:
Impact of Data and Network Issues: The high percentage of participants who agreed (66.7%) and somewhat agreed (25%) suggests that students' data and network issues have had a notable negative impact on online teaching and learning.

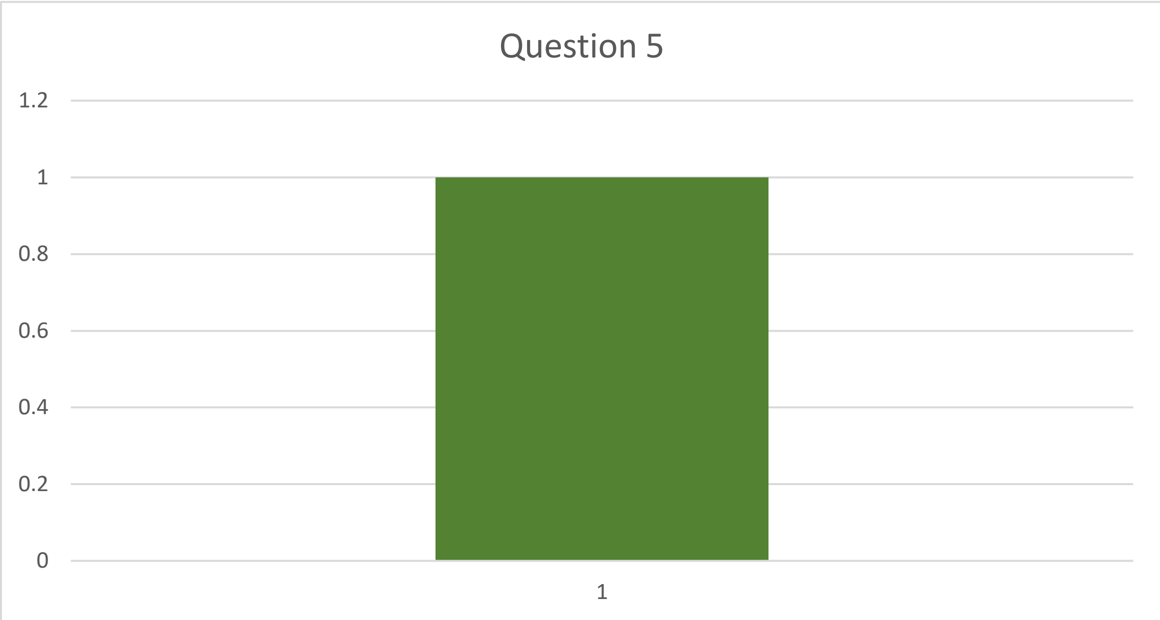
Disruptions in Learning: Data and network problems can disrupt students' ability to access online classes, resources, and interactive platforms, affecting the continuity of their learning.

Inequitable Learning Experience: Students facing data and network challenges might experience inequities in their online learning experience, as they may be unable to participate fully or access all educational content.

Need for Improved Connectivity: The response highlights the need for improved internet connectivity and data access for students to facilitate effective online learning.

Importance of Addressing Technical Challenges: Addressing students' data and network issues is crucial to ensure an inclusive and accessible online learning environment for all learners.

Figure 5:
Graphical representation of Question 5



Analysis of Question 6:
The Likert scale response to Question 6, which assesses whether the Department of Electronic Engineering educators are adequately skilled and trained in online pedagogy, reveals a mixed sentiment among the participants. The responses in Figure 6 below show distribution across various options, with 16.7% somewhat agreeing, 16.7% remaining neutral, 33.3% somewhat disagreeing, and 33.3% agreeing.

Implications:
Lack of Consensus: The distribution of responses across different options indicates a lack of consensus among the participants regarding the educators' online pedagogy skills and training.

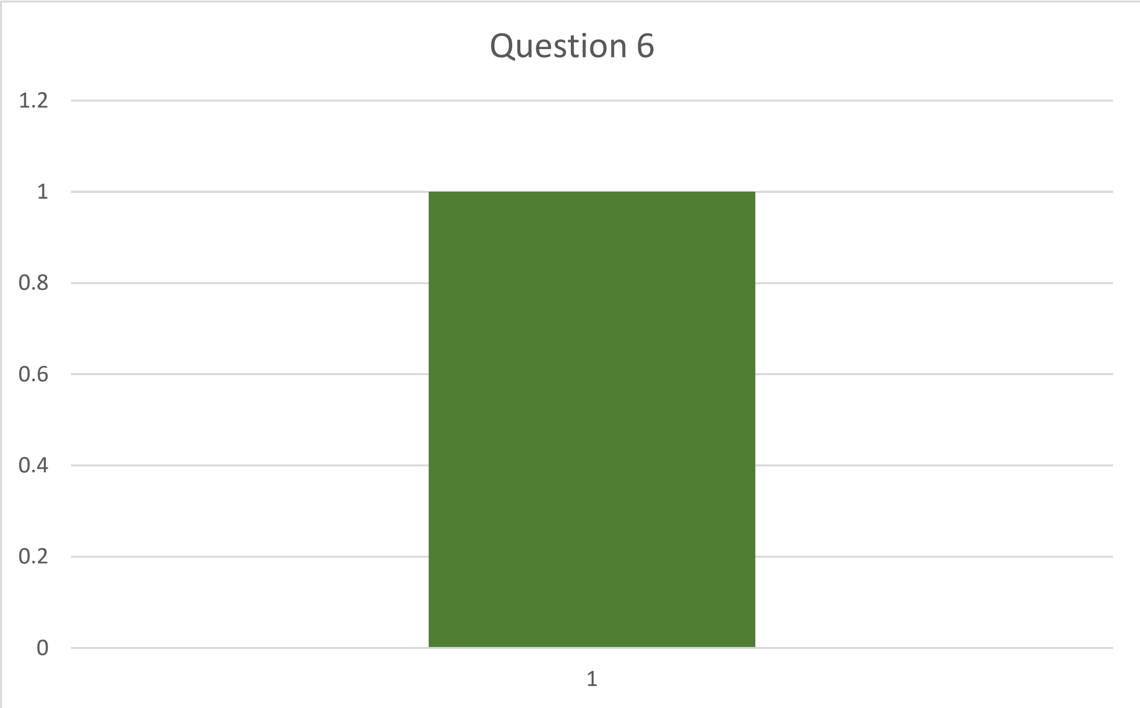
Skill and Training Gaps: The relatively high percentages of participants who somewhat disagree and remain neutral suggest the existence of potential skill and training gaps among some educators in the department.

Need for Improvement: The mixed responses highlight the importance of addressing the challenges related to online pedagogy to enhance the effectiveness of online teaching and learning.

Impact on Student Experience: Educators' proficiency in online pedagogy can significantly impact the quality of the student learning experience and engagement in online classes.

Importance of Professional Development: The results underscore the significance of providing ongoing professional development opportunities for educators to enhance their online teaching skills.

Figure 6:
Graphical representation of Question 6



Analysis of Question 7:
The Likert scale response to Question 7, evaluates whether online simulation programs like MATLAB and Multisim adequate replacements for traditional practicals are, indicates a negative sentiment among the participants. The responses in Figure 7 below show a distribution across different options, with 16.7% being neutral, 25% somewhat agreeing, and 50% disagreeing.

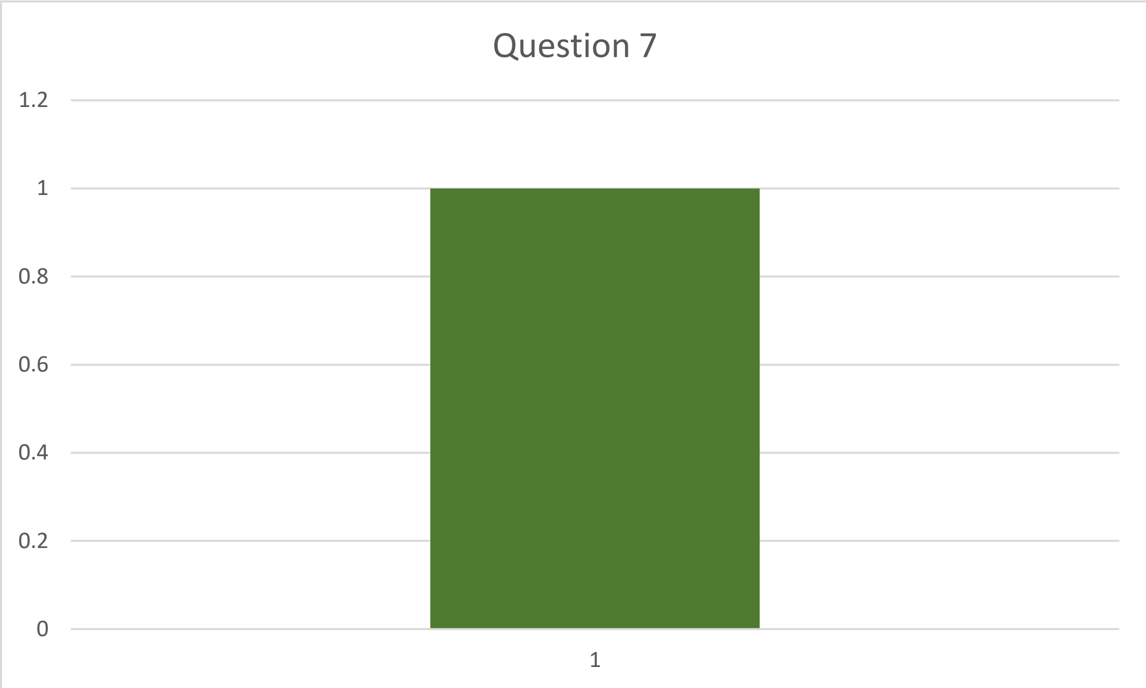
Implications:
Low Agreement: The combined percentage of participants who somewhat agree and agree (25%) is significantly lower than the percentage who disagree (50%), indicating a lack of support for online simulation programs as replacements for traditional practicals.

Concerns about Adequacy: The relatively high percentage of participants disagreeing suggests that many believe online simulation programs may not adequately replace the hands-on experience offered by traditional practicals.

Importance of Hands-On Learning: The responses highlight the value participants place on hands-on learning experiences, which are not fully replicated through online simulations.

Impact on Skill Development: Participants' reluctance to see online simulations as adequate replacements raises concerns about the potential impact on students' practical skills and abilities.8
Need for Hybrid Approaches: The mixed responses indicate that a combination of both traditional practicals and online simulations might be more effective in providing a comprehensive learning experience.

Figure 7:
Graphical representation of Question 7



Analysis of Question 8:

The Likert scale response to Question 8, which assesses whether educators were given adequate guidelines and policies for remote pedagogy during the pandemic, reveals a concerning sentiment among the participants. The responses in Figure 8 below show a distribution across different options, with only 16.7% agreeing, 8.3% somewhat agreeing, 8.3% remaining neutral, 16.7% somewhat disagreeing, and 50% disagreeing.

Implications:

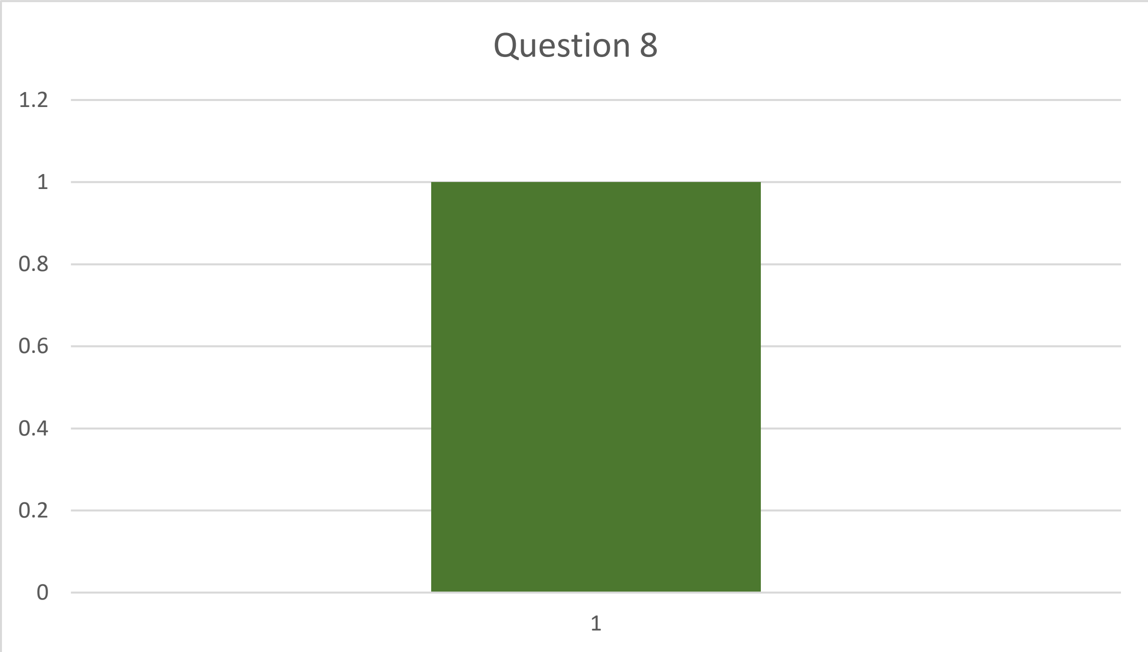
Lack of Agreement: The combined percentage of participants who agree and somewhat agree (25%) is significantly lower than the percentage who disagree (50%), indicating a lack of consensus on whether educators were provided with adequate guidelines and policies.

Concerns About Support: The relatively high percentage of participants disagreeing suggests that many educators felt they did not receive sufficient support in navigating remote pedagogy during the pandemic.

Impact on Pedagogical Quality: The responses raise concerns about the potential impact of inadequate guidelines and policies on the quality of remote teaching and learning experiences.

Importance of Clear Guidance: The mixed responses highlight the importance of clear and comprehensive guidelines and policies to help educators effectively adapt to remote teaching.

Figure 8:
Graphical representation of Question 8



Analysis of Question 9:

The Likert scale response to Question 9, evaluates the effectiveness of the learning management system (LMS) Moodle for online teaching and learning, reveals a mixed sentiment among the participants. The responses (see below) are distributed across various options, with only 16.7% agreeing, 8.3% somewhat agreeing, 8.3% remaining neutral, 16.7% somewhat disagreeing, and 41.7% disagreeing.

Implications:

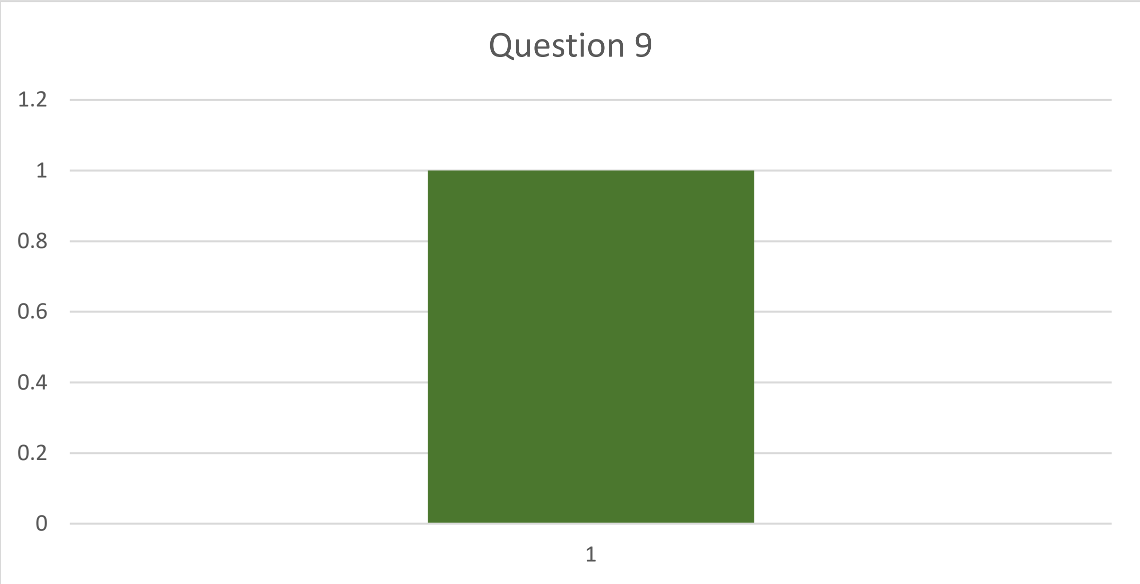
Lack of Agreement: The combined percentage of participants who agree and somewhat agree (25%) is significantly lower than the percentage who disagree (58.4%), indicating a lack of consensus on Moodle's effectiveness in meeting the department's requirements.

Concerns About LMS Effectiveness: The relatively high percentage of participants disagreeing suggests that many participants do not believe Moodle fully meets the department's requirements for online teaching and learning.

Need for Improvement: The mixed responses highlight the need to identify specific areas where Moodle may be falling short and take measures to enhance its effectiveness.

Impact on Teaching and Learning: The perceived effectiveness of the LMS can significantly impact the overall quality of online teaching and learning experiences.

Figure 9:
Graphical representation of Question 9



Analysis of Question 10:
The Likert scale response to Question 10, which assesses the impact of online teaching and learning during the pandemic on educators' mental health and well-being, reveals a concerning sentiment among the participants as shown below. The majority (75%) agreed with the statement, and a smaller proportion (25%) somewhat agreed.

Implications:
High Agreement: The combined percentage of participants who agree and somewhat agree (100%) indicates a strong consensus that educators' mental health and well-being have been negatively impacted by online teaching and learning during the pandemic.

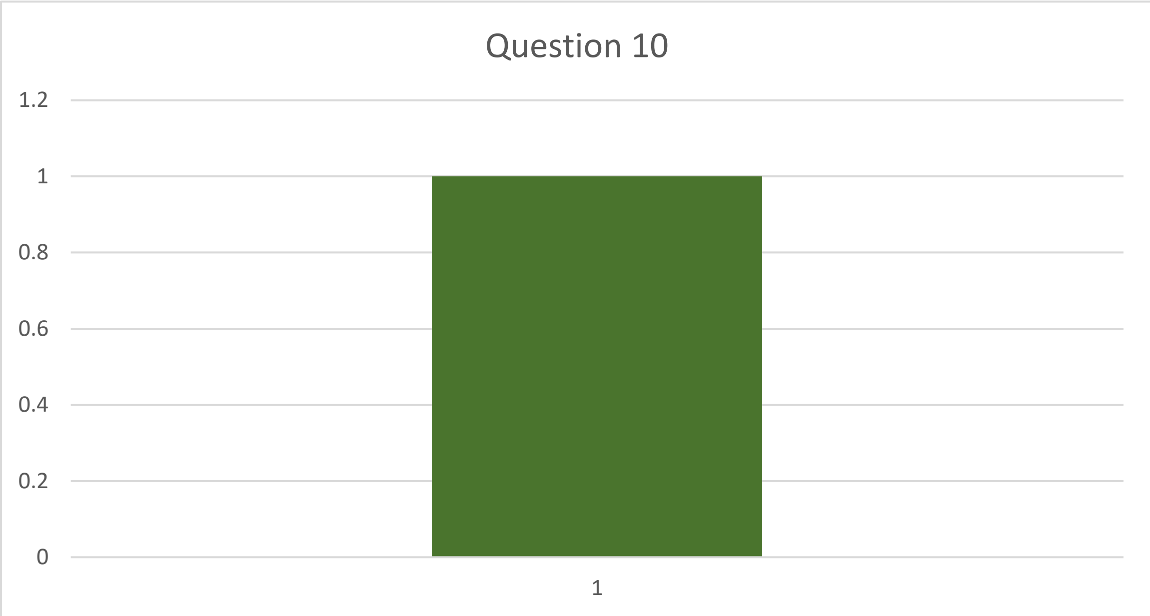
Stress and Challenges: The high agreement percentage highlights the significant stress and challenges educators faced while transitioning to online teaching and coping with the uncertainties and changes brought about by the pandemic.

Importance of Mental Health Support: The response underscores the importance of providing adequate support and resources to address educators' mental health and well-being during challenging times.

Potential Impact on Teaching Quality: The negative impact on educators' mental health may affect their teaching effectiveness and overall job satisfaction.

Need for Work-Life Balance: The responses emphasize the need to ensure a healthy work-life balance for educators to prevent burnout and promote well-being.

Figure 10:
Graphical representation of Question 10



Analysis of Question 11:
The Likert scale response to Question 11, which assesses the effectiveness of conducting the qualification offered in the Department of Electronic Engineering using online teaching and learning tools only, reveals a concerning sentiment among the participants. The responses, as shown below, are distributed across various options, with 25% somewhat agreeing, 16.7% somewhat disagreeing, and 58.3% disagreeing.

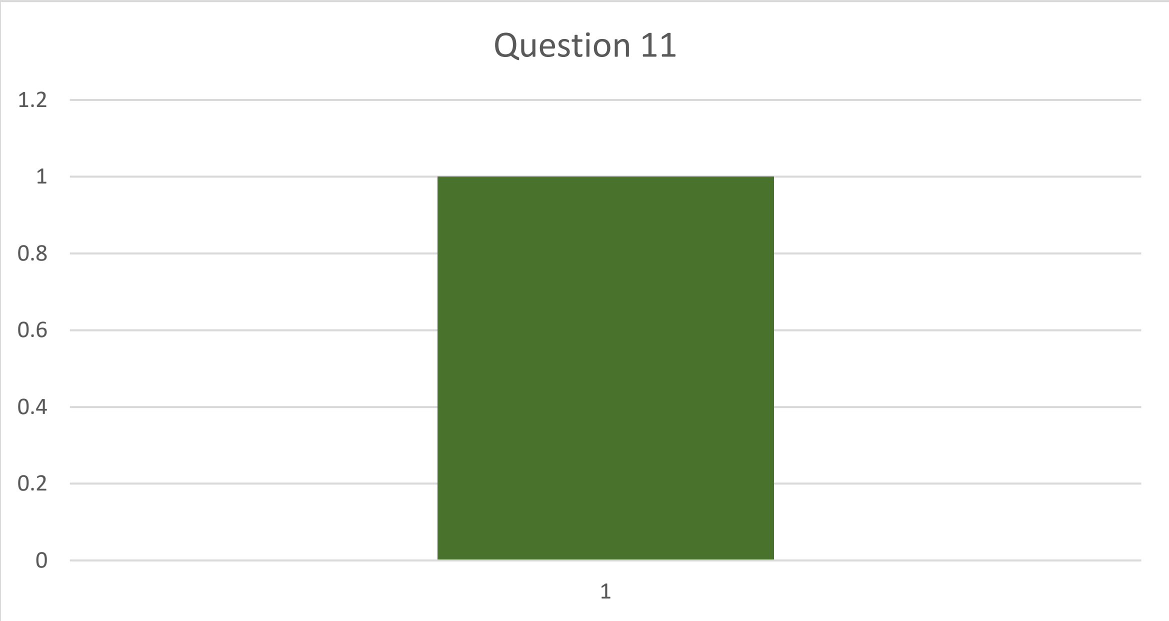
Implications:
Lack of Agreement: The combined percentage of participants who somewhat agree and somewhat disagree (41.7%) is significantly lower than the percentage who disagree (58.3%), indicating a lack of consensus on whether online teaching and learning tools alone are effective for conducting the qualification.

Concerns About Online-Only Delivery: The relatively high percentage of participants disagreeing suggests that many believe online teaching and learning tools alone may not be sufficient to effectively deliver the qualification.

Importance of Blended Approach: The mixed responses highlight the importance of a blended approach that incorporates both online and in-person teaching methods.

Potential Limitations of Online Tools: The responses raise concerns about the potential limitations of online tools in delivering practical components and hands-on learning experiences.

Figure 11:
Graphical representation of Question 11



SWOT analysis of the qualitative data collected from the survey
The staff members (participants) in the Department of Electronic Engineering were asked to complete a four-question survey focused on the strengths, weaknesses, opportunities, and threats to the department from the educator's perspective. The participants' responses to each SWOT-related question are categorized by linking keywords and meanings in each statement in Table 2.

Table 2:
SWOT Analysis of Respondent's Responses

STRENGTHS	WEAKNESSES
Research: The department seems to have a strong focus on research, which can enhance the academic reputation and contribute to advancements in the field.	**Lack of Communication and Meetings:** Poor communication and infrequent meetings can lead to misunderstandings, lack of collaboration, and hinder the flow of information. **No Formal Guidelines:** The absence of formal guidelines can result in uncertainty and inconsistency in decision-making processes. **Lack of Support from Management:** Insufficient support from management may lead to demotivated staff and hinder their productivity. **Fewer Educators and Staff Reduction:** A shortage of educators and staff due to retrenchment and resignations can strain the department's capacity and increase workloads on existing employees. **Inadequate Infrastructure and Resources:** The

	department's inability to accommodate student numbers and a lack of resources might negatively impact the learning experience. **Shortage of Skilled Educators:** The retirement of experienced educators can result in a lack of expertise and knowledge transfer within the department. **Weak Management and Leadership:** Weak leadership may lead to unclear direction, inefficient decision-making, and staff dissatisfaction. **Fear of Discussing Challenges:** An environment where staff are afraid to voice their challenges to management can hinder problem-solving and improvement efforts. **Lack of Accommodations for Disruptions:** Failure to accommodate disruptions to the academic program might result in further challenges for both students and educators. **Ineffective Solutions from Management:** Management's inability to provide effective solutions to identified problems can impede progress and cause frustration among staff. **Enforcing Key Performance Indicators during the Pandemic:** Imposing strict performance indicators during a pandemic may be counterproductive and demoralize staff. **Impact of No Hands-On Practicals:** The absence of hands-on practicals for students can negatively affect their learning outcomes and preparedness for real-world scenarios.
Research and Collaboration: Leveraging research opportunities can lead to academic advancements and potential collaborations with other institutions or industries. Staff Collaboration for Solutions: Encouraging teamwork and collaboration among staff can lead to innovative solutions for departmental challenges. Development of Online Pedagogy: Investing in the development of online teaching methods can improve the department's ability to adapt to changing educational landscapes. Hybrid Teaching and Learning: Implementing hybrid teaching approaches can offer flexibility to students and provide a better learning experience. Training Staff on Technologies: Providing training for staff on emerging technologies	**Staff Turnover:** High staff turnover can disrupt the department's stability and continuity, leading to a loss of institutional knowledge. **Quality Issues with Online Assessments:** Poorly managed online assessments can compromise the academic integrity and quality of education. **Accreditation Concerns:** A potential loss of accreditation can severely impact the reputation and credibility of the department's qualification. **Low Staff Morale and Well-being:** A negative work environment, poor support, and mental health issues can reduce productivity and increase staff attrition. **Retention of Experienced Staff:** Difficulty retaining experienced staff might lead to losing expertise and disrupt the department's continuity. **Hostile Work Environment:** A hostile work environment can lead to decreased productivity

can enhance their teaching abilities and student engagement.	and collaboration among staff. **Impact on Quality of Graduates:** Insufficient direction and leadership may result in graduates lacking the necessary skills and qualifications desired by employers. **Industry Confidence in the Qualification:** A loss of confidence from the industry in the department's qualification can affect job prospects for graduates. **Insufficient Direction and Leadership:** Lack of clear direction and leadership can hinder progress and hinder the department's ability to address challenges effectively.

CONCLUSION AND RECOMMENDATIONS

The analysis of the Likert scale responses has important implications for the Department of Electronic Engineering's online teaching practices. Participants expressed a lack of consensus and significant concerns regarding the effectiveness of online tools for conducting the qualification. The high percentage of disagreement suggests that online teaching and learning tools alone may not fully meet the department's requirements, especially in delivering practical components and hands-on learning experiences. This highlights the importance of adopting a blended approach that combines online tools with in-person teaching methods to address the limitations of online-only delivery. Additionally, the analysis emphasizes the need for continuous evaluation, professional development, and student feedback to optimize the use of online tools and enhance the overall quality of the qualification delivery. The SWOT analysis highlights several critical areas for the department to address. Capitalizing on research opportunities, improving communication, providing better support and resources, and promoting staff collaboration are potential areas for improvement. Addressing the threats of staff turnover, accreditation concerns, and maintaining staff morale and well-being should also be prioritized. To seize opportunities and mitigate threats effectively, the department must develop clear strategies and implement actionable plans to improve overall performance and achieve its goals. By implementing these recommendations, the department can work towards creating a more comprehensive and impactful learning experience for students while effectively addressing the challenges posed by online teaching and learning during the pandemic and beyond.

Contribution to knowledge

The analysis of survey responses regarding online teaching practices in the Department of Electronic Engineering contributes valuable insights to the field of education during the pandemic and highlights significant implications for improving instructional approaches. The study revealed that participants were skeptical about the effectiveness of conducting the qualification solely through online teaching tools. The findings emphasize the need for a balanced and blended approach that incorporates both online tools and in-person teaching methods, particularly for delivering practical components and hands-on learning experiences. This contribution sheds light on the challenges educators face in navigating remote pedagogy and the potential impact on students' learning outcomes. The study underscores the importance of continuous evaluation, professional development, and student feedback to optimize the use of online tools and ensure a comprehensive and impactful learning experience. By addressing these implications, educational institutions can better adapt to remote teaching during challenging times, fostering resilience and innovation in the field of online education.

Recommendations to the Department of Electronic Engineering

The provided recommendations offer valuable guidance for improving the effectiveness of online teaching practices in the Department of Electronic Engineering. By conducting a detailed analysis of survey responses and addressing the identified challenges, the department can enhance instructional approaches and ensure a more positive learning experience. Offering training and support to educators and students in digital literacy and online tools will bolster their proficiency in online teaching.

Establishing clear communication channels and investing in technological infrastructure will create a more seamless and user-friendly learning environment. By continuously reviewing and adapting pedagogical approaches, the department can engage students effectively during remote learning. The cyclical assessment process will enable continuous improvement and ensure the department remains adaptable in challenging times.

Additionally, the recommendations for technical support underscore the importance of assessing educators' needs and providing tailored assistance to enhance their proficiency in using technology effectively. Collaboration with the IT department will ensure seamless integration of technology in teaching and learning.

To maintain academic integrity, the department should implement robust security measures for online assessments and promote a culture of academic honesty. Diversifying assessment strategies and encouraging active learning will reduce opportunities for cheating and improve student engagement.

To address challenges posed by load shedding and students' data and network issues, developing contingency plans, offering offline resources, and collaborating with utility providers will ensure uninterrupted access to education. Supporting educators' mental health and well-being will foster a positive teaching environment and ultimately benefit student learning outcomes.

Furthermore, evaluating the effectiveness of online simulation programs and addressing skill development concerns will complement traditional practicals. Improving guidelines and policies for remote pedagogy and optimizing the Learning Management System will enhance the online learning experience.

By incorporating these recommendations, the Department of Electronic Engineering can effectively adapt to the demands of online education during the pandemic and foster resilience and innovation in the field of online teaching and learning.

Recommendations for future work

This research study has uncovered several significant findings and conclusions. It aimed to evoke further discussions and research leading to the final dissertation. The researcher believes that this research study will stimulate further research given the impact of the topic globally. As this research study was limited to the educator's perspective, the following recommendations are presented as an opportunity for additional research in the field. Further investigation into online learning from a student's perspective. This should expose the numerous challenges that are experienced by students living in a developing nation. Online teaching and learning must be considered during the pandemic when students are on campus and have access to technology and necessities, as well as during national lockdowns when students are back home in rural villages and towns. A strategy for online teaching and learning must be considered to be inclusive of the external factors of the institution such as the high unemployment rate of the country, lack of service delivery, and the mental health and well-being of the students. These all have a direct impact on the student's performance in academia.

REFERENCES

Abdulkareem, T.A. & Eidan, S.M. (2020) Online Learning for Higher Education Continuity (during COVID-19 Pandemic). *International Journal of Youth Economy* 4(2) pp.125-134.

Ahmad, S., Wasim, S., Irfan, S., Gogoi, S., Srivastava, A. & Farheen, Z. (2019) Qualitative v/s. Quantitative Research- A Summarized Review. *Journal of Evidence Based Medicine and Healthcare* 6(43) pp.2349-2570.

Bania, J. & Banerjee, I. (2020) Impact of Covid-19 Pandemic on Higher Education: A Critical Review. Higher Education after the COVID-19 crisis. *Global University Network for Innovation* pp.1-12.

Berry, B., Doucet, A. & Owens, B. (2020) *Teacher Leadership in the Aftermath of a Pandemic: The Now, The Dance, The Transformation.* s.l.:Education International.

Calonge, D.S., Connor, M., Hultberg, P., Shah, M.A. & Aguerrebere, P.M. (2022) Contactless Higher Education: A SWOT Analysis of Emergency Remote Teaching and Learning during COVID-19. *Journal of Educational Studies and Multidisciplinary Approaches* 2(1) pp.18-36.

Carrillo, C. & Flores, M.A. (2020) COVID-19 and teacher education: a literature review of online teaching and learning practices. *European Journal of Teacher Education* 43(4) pp.466-487 .

Gherhes, V., Stoian, C.E., Fărcasiu, M.A. & Stanici, M. (2021) E-Learning vs. Face-To-Face Learning: Analyzing Students' Preferences and Behaviors. *Sustainability* 13(8) p.4381.

He, W. & Xiao, J. (2020) The Emergency Online Classes During COVID-19 Pandemic: A Chinese University Case Study. *Asian Journal of Distance Education* 15(2) pp.21-36.

Hollweck, T. & Doucet, A. (2020) Pracademics in the pandemic: pedagogies and professionalism. *Journal of Professional Capital and Community* 5(3/4) pp.295-305.

Hox, J.J. & Boeije, H.R. (2005) Data Collection, Primary vs Secondary. *Encyclopedia of Social Measurement* 1(1) pp.593-599.

Kabir, S.M.S. (2016) *Basic Guidelines for Research: An Introductory Approach for All Disciplines,* Chittagong: Book Zone Publication, pp.201-275.

Kelly, L.M. & Cordeiro, M. (2020) Three principles of pragmatism for research on organizational processes. *Methodological Innovations* 13(2) pp.1-10.

Kim, K.-J. & Bonk, C.J. (2006) The Future of online teaching and learning in higher education: The Survey Says. *Educause Quarterly* pp.22-30.

Kivunja, C. & Kuyini, A.B. (2017) Understanding and Applying Research Paradigms in Educational Contexts. *International Journal of Higher Education* 6(5) pp.26-41.

König, J., Jäger-Biela, D. J. & Glutsch, N. (2020) Adapting to online teaching during COVID-19 school closure: teacher education and teacher competence effects among early career teachers in Germany. *European Journal of Teacher Education* 43(4) pp.608-622.

Nortvig, A-M., Petersen, A.K. & Balle, S.H. (2018) A Literature Review of the Factors Influencing E-Learning and Blended Learning in Relation to Learning Outcome, Student Satisfaction and Engagement. *The Electronic Journal of e-Learning* 16(1) pp.46-55.

Pokhrel, S. & Chhetri, R. (2021) A Literature Review on Impact of COVID 19 Pandemic on Teaching and Learning. *Higher Education for the Future* pp.1-9.

Ponto, J. (2015) Understanding and Evaluating Survey Research. *Journal of the Advanced Practitioner in Oncology* 6(2) pp.168-171.

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) p.1851.

Tran, T.T. (2017) Research choice: Pragmatism in conducting research about university enterprise collaboration in the Vietnamese context. *Network of Scientific Journals from Latin America, the Caribbean, Spain and Portugal* pp.67-80.

van Niekerk, R.L. & van Gent, M.M. (2021) Mental health and well-being of university staff during the coronavirus disease 2019 levels 4 and 5 lockdowns in an Eastern Cape University in South Africa. *South African Journal of Psychiatry* 9(6) pp.64-70.

Zalat, M.M., Hamed, M.S. & Bolbol, S.A. (2021) The experiences, challenges, and acceptance of e-learning as a tool for teaching during the COVID-19 pandemic among university medical staff. *PLOS ONE,* 16(3) pp.e0248758

Academics' perceptions on online continuous professional development in higher education[4][5]

Sibongile Simelane-Mnisi, Tshwane University of Technology, South Africa
ORCID: 0000-0002-4213-7959

ABSTRACT

This study aimed to investigate academics' perceptions of online continuous professional development (OCPD) and the design and development of online modules in higher education. Fourteen academics from one faculty at the University of Technology in South Africa participated. In selecting the participants for this study, purposive and convenient sampling was applied. A qualitative case study approach was used. Data were collected through semi-structured interviews and open-ended questionnaires. Saldaña's thematic approach to analysis was used to analyse data using Atlas.ti. It was found that most of the academics who attended OCPD were able to build their module on IMFUNDO because the instructional designer provided the module structure or template. The findings revealed that the university's eChampions contributed immensely during the process by providing additional support in the departments. It is recommended that further studies be conducted on the students' perceptions of implementing the IMFUNDO modules developed in this study.

Keywords: academics' perceptions, online continuous professional development, instructional designers, online modules, higher education

INTRODUCTION

A transition from traditional to virtual learning has occurred over the past twenty years, particularly in continuing professional education and among non-traditional adult learners (Buxton, Burns & De Muth, 2012). Online learning is now a ubiquitous feature of the educational environment. Also, how academics are supported in creating online teaching methods is a key component of students' learning experience (Evans et al., 2020). It is critical when utilising online learning, to create learning technologies in a way that they encourage meaningful interaction because interaction influences students' perception of a technology's usability and value in achieving their learning objectives (Tawfik et al., 2022). Therefore, academics must encourage student engagement in an online environment by creating learning activities that foster engagement, interaction and participation.

[4] The author thanks the National Research Funding and University Capacity Development Grant for financial support of the project.

[5] Date of Submission: 31 January 2023

Date of Review Outcome: 28 July 2023

Date of Acceptance: 20 August 2023

For academics to be able to design and develop such learning materials, support from instructional designers is needed. Instructional designers have an in-depth understanding and vast knowledge of their field. Instructional design encompasses the process of creating learning experiences and materials by assessing needs, objectives, gaps and challenges, creating a plan, learning space and resources, and then developing material that engages learners with meaningful content, clear and purposeful activities, as well as evaluating the material's effectiveness (Power, 2019). For academics to apply these skills to design and develop their module, there has to be support from instructional designers (ID) through the use of relevant instructional design principles.

During the outbreak of the COVID-19 pandemic, professional development webinars supported higher education practitioners (Al-Naabi, 2023). At a Study University of Technology, the academics were empowered via online continuous professional development offered in webinars on the design and development of their modules on the learning management system known as IMFUNDO (Simelane-Mnisi, 2022a). IMFUNDO is the pseudonym for the learning management system (LMS) used at the university under study in this article (Simelane-Mnisi & Mji, 2020; Simelane-Mnisi & Mokgalaka-Fleischmann, 2022). In order to ensure that academics use effective design in their learning materials, the IMFUNDO teaching and empowerment [training] framework (ITEF) was used to improve the academics' digital competencies (Simelane-Mnisi, 2022b). The framework ensured that the online materials' quality standards were maintained. This was accomplished using modules from the Higher Education Qualifications Framework. Technology was incorporated into the curriculum to develop these modules, with the emphasis on constructive alignment.

This study investigated academics' perceptions of OCPD in higher education that focused on the IMFUNDO module design and development. Shahzad et al., (2023) argue that e-learning for continued professional development requires incorporating emerging technologies in line with changing job requirements and ensuring organisational sustainability. The argument from these authors suggests the significance of implementing continual development programs to make sure that the academics at the study university stay current with the digital change in education. This study investigates academics' perceptions of the OCPD programme on the design and development of online modules utilising open-ended and closed-ended questionnaires and interviews.

LITERATURE REVIEW

Professional Development Webinars for Educational Purposes

Evans et al. (2020) state that the purpose of the professional development course is to show academics how to use the Blackboard LMS's features and functions in various ways to assist student learning. It is essential to incorporate developing technologies in line with changing job requirements and ensure organisational sustainability when using e-learning for continued professional development (CPD) (Shahzad et al., 2023). Li and Yu (2022) argue that to fully utilise e-learning environments, effective individual academic professional development requires basic digital literacy. The study conducted in Hong Kong by Evans et al. (2020) revealed that the preferred method of professional development was blended learning which was effective in facilitating enhanced usage of the university's LMS. It may be argued in this study that a series of OCPD was conducted online to prepare academics to set up the learning material on IMFUNDO.

A growing number of educational institutions are using webinars to disseminate knowledge and skills in a way that has a significant and widespread impact (Amado-Salvatierra, Rizzardini & Chan, 2020; Buxton, et al., 2012). Webinars are digital technologies for delivering education and training through synchronous audiovisual communication between participants and academics who are remotely located (Gegenfurtner & Ebner, 2019). Higher education institutions should tailor webinar provisions to the demands and teaching and learning situations of their academic staff members to provide better and more effective professional development webinars (Al-Naabi, 2023). The professional development webinars reported in Al-Naabi (2023) covered topics relating to online pedagogy, course management systems, technologies for online teaching and learning, and online assessment. The OCPD proved successful as academics implemented their modules with students because they had the necessary skills and competencies to design and develop the online modules that fostered student engagement.

Academics' perception of webinar professional development

Librarians' continuous professional development is crucial to improve institutions in the present technology-driven world (Shahzad et al., 2023). For the academics in O'Dowd's (2022) study, participating in initiatives involving virtual environments gave academics excellent experience in methodological innovation and ongoing professional growth. It is for these reasons that this study sought to examine academics' perceptions of the OCPD programme whether it would yield similar sentiments. Academics believed that teacher collaboration was critical when dealing with creative activities such as integrating technology into teaching (O'Dowd, 2022).

Li and Yu (2022) found that some academics considered digital literacy training time-consuming and demanding. Amado-Salvatierra et al. (2020) reported that nonverbal cues, including body language, facial expression, and eye contact, are lost during the webinar session. Participants may become quickly distracted if the webinar is not engaging or moving along at a good speed (Gegenfurtner & Ebner, 2019). For some academics, participating in existing professional development programmes for digital competence felt difficult (Li & Yu, 2022). Nevertheless, although the differences were negligibly minor, webinars were slightly more effective than the control circumstances of online asynchronous LMSs and offline, face-to-face classroom training (Gegenfurtner & Ebner, 2019).

STUDY METHOD

In order to fulfil the aim of the study, the following question is posed: How do academics perceive the online continuous professional development (OCPD) for online module design and development? In order to answer this question, a qualitative case study was employed. This study used qualitative research grounded in the social constructivist paradigm, which holds that people seek an understanding of the world in which they live and work (Creswell, 2014). Hence, the researcher heavily relied on the participants' perspectives to understand the phenomenon being studied. A case study is a critical examination of a small sample of a particular real-world initiative, policy, institution, programme or system from several angles to understand its complexity and uniqueness (Cohen, Manion & Morrison, 2018). Data were gathered through semi-structured interviews and open-ended questionnaires. Saldaña's thematic approach to analysis was used to analyse data (Saldaña, 2015). Finding meaning patterns (themes) through codes is a thematic analysis method (Saldaña, 2021). University approval was gained for this research's ethical conduct. The names used in the analysis of this study are pseudonyms.

Participants

The participating academics were selected from the population of one faculty at the University. In selecting the participants, purposive and convenient sampling were applied. The researcher purposefully selected participants from the Faculty of Science who were knowledgeable about the subject to best assist the researcher in understanding the problem and responding to the research question (Creswell & Creswell, 2018). Participants were also selected conveniently because the researcher was the ID who conducted the OCDP, and the academics were available and easily accessible at the time (Cohen et al., 2018). Fourteen academics from 14 departments in the Faculty of Science participated in the study. These academics attended the OCPD and designed and implemented their modules on the LMS.

Instrument and procedure

This study used open-ended questionnaires and semi-structured interviews to gather data from the participants.

Open-ended questionnaire

A semi-structured open-ended questionnaire was employed whereby the participants were asked to respond or comment on questions and statements. The semi-structured open-ended questionnaire provides a clear structure, sequence and focus; however, an open-ended format enables participants to reply in their own terms/words (Cohen et al., 2018). This study's questionnaire consisted of four questions:

- How did you experience the IMFUNDO continuous professional development?
- What did you learn from the OCPD?
- How will you evaluate the time given to prepare the learning design of your online modules on IMFUNDO?
- Indicate the support provided for you to design, develop and implement your online module.

Semi-structured interviews

Individual, semi-structured interviews were used. These interviews enabled the researcher to explore issues in greater depth, to understand how and why academics framed their thoughts in particular ways, and to understand how and why they related concepts, values, events, attitudes and behaviours (Cohen et al., 2018). Open-ended questions were mirrored in the interview questions. Skype was used to conduct the interviews online. Following transcription, the academics received the transcripts of the recorded interviews to confirm that the information had been correctly recorded.

FINDINGS AND DISCUSSION

The Atlas.ti Project titled 'IMFUNDO Continuous Professional Development' was developed through qualitative data analysis. The project included two primary documents relating to open-ended questions and interviews. The researcher created 36 codes. These codes were then grouped into four networks relating to IMFUNDO, learned, time, and support.

IMFUNDO

Academics were requested to respond to the question: How did you experience the IMFUNDO continuous professional development? From this question, the researcher generated 13 codes clustered into the theme IMFUNDO. Figure 1 shows the conceptual network IMFUNDO. It was found that the academics appreciated the opportunity to attend the OCPD on the learning design of online modules using the IMFUNDO. Dr Mtshali indicated that IMFUNDO offered a world-class platform for teaching and learning, and he was able to incorporate the practical component of the module on this platform. Mrs Mokoena reported that the IMFUNDO system offered more opportunities. Literature revealed that to upskill academics in digital delivery and improve the student experience, staff development is essential to ensure that specialised assistance for technology-enhanced learning is provided (Sumer, Douglas & Sim, 2021).

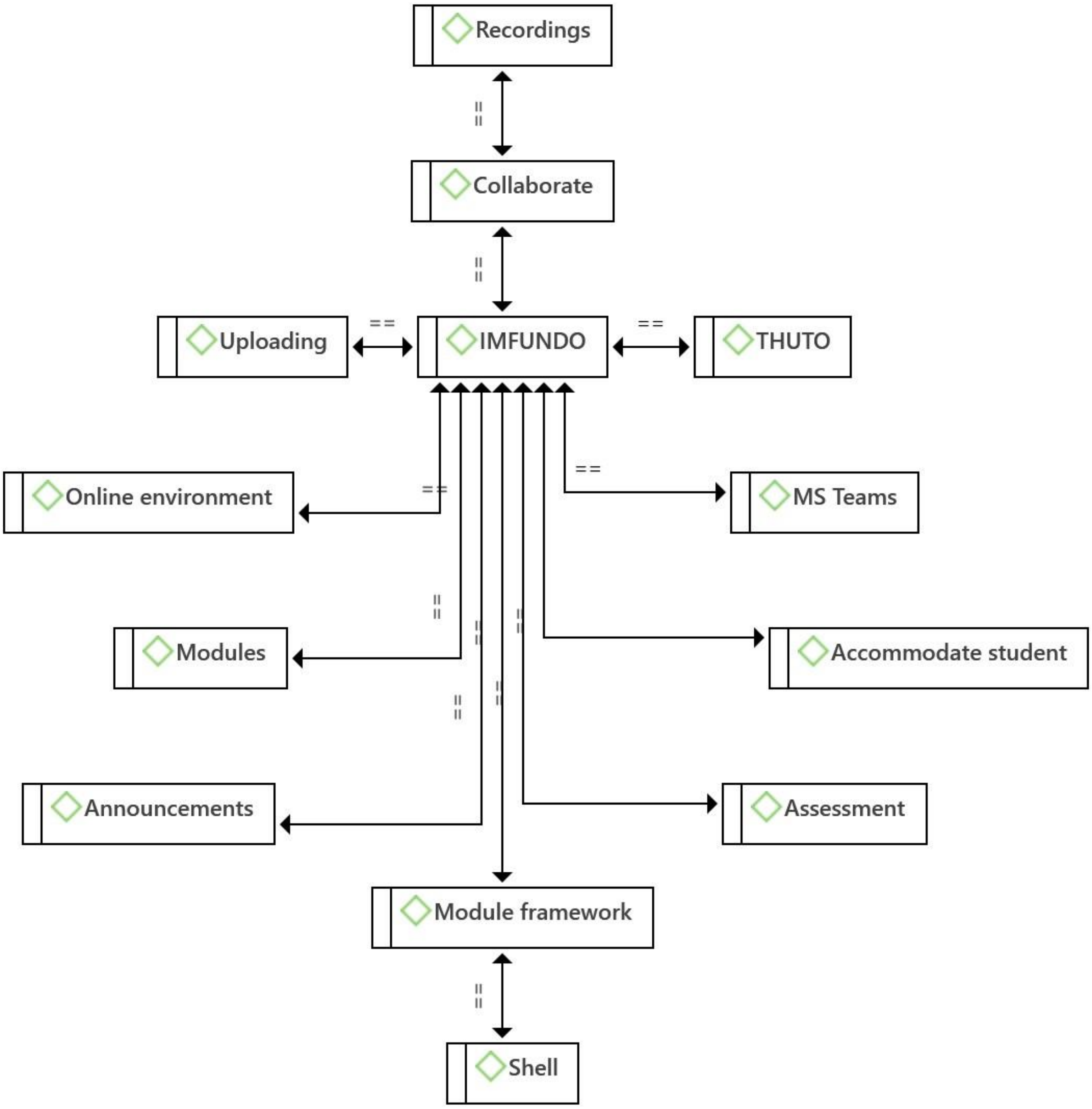
The findings revealed that most academics who attended our OCPD programme could build their module on IMFUNDO because the ID in the Faculty provided the module structure or template. Prof Adam indicated that, during the IMFUNDO OCPD programme, after the ID demonstrated the use of the online module framework, he was able to build the module. Dr Mooi mentioned that all her modules were already on IMFUNDO. For Ms Coetzer, designing module content on the new shell/template was not too difficult. These findings are supported by Cho et al. (2021) who showed that the LMS standard template/structure works. Simelane-Mnisi (2022) emphasised that the LMS template should be customised to suit the module offering as a one-size-fits-all template proved ineffective.

The online empowerment sessions were recorded using virtual conferencing tools such as Microsoft Teams or Collaborate. Mrs Mafa mentioned that the ID made professional development recordings available on the online module on IMFUNDO for future reference. Al-Naabi (2023) argued that webinars allowed for flexible lifelong learning engagement, programme delivery of professional development, and the development of academics' digital skills. This author asserted that academics who took part in webinars learned more about synchronous and asynchronous teaching techniques and were able to collaborate and discuss online pedagogy in a professional context.

It was discovered that academics uploaded learning material and created assessment activities to encourage student engagement in the online environment. Mr Botha mentioned that IMFUNDO contained numerous materials for the students to access. Mrs Hlaba indicated that the overall planning and teaching design was effective. She created assessment activities to ensure that students learn the material in the online environment. Research showed the impact of ID empowerment support for academics in designing and developing learning material was beneficial because of the increased use of LMS tools that encourages interactivity (Budiantara, Mustaji & Setyowati, 2023). These authors identified activities relating to teaching presence, learning videos, quizzes, discussion features, and task collecting points. Ms Ndlovu reported that she learned to accommodate and attend to students using IMFUNDO and to send announcements. Budiantara et al. (2023) argued that, compared to traditional methods, incorporating LMS tools can enhance learning outcomes and encourage student engagement with the activities posted by academics. The number of activities used, such as presence, learning videos, modules, quizzes, discussion features, and task collecting points, increased as a result of ID empowerment support for academics in designing and developing learning material, according to research (Budiantara, et al., 2023).

Figure 1:

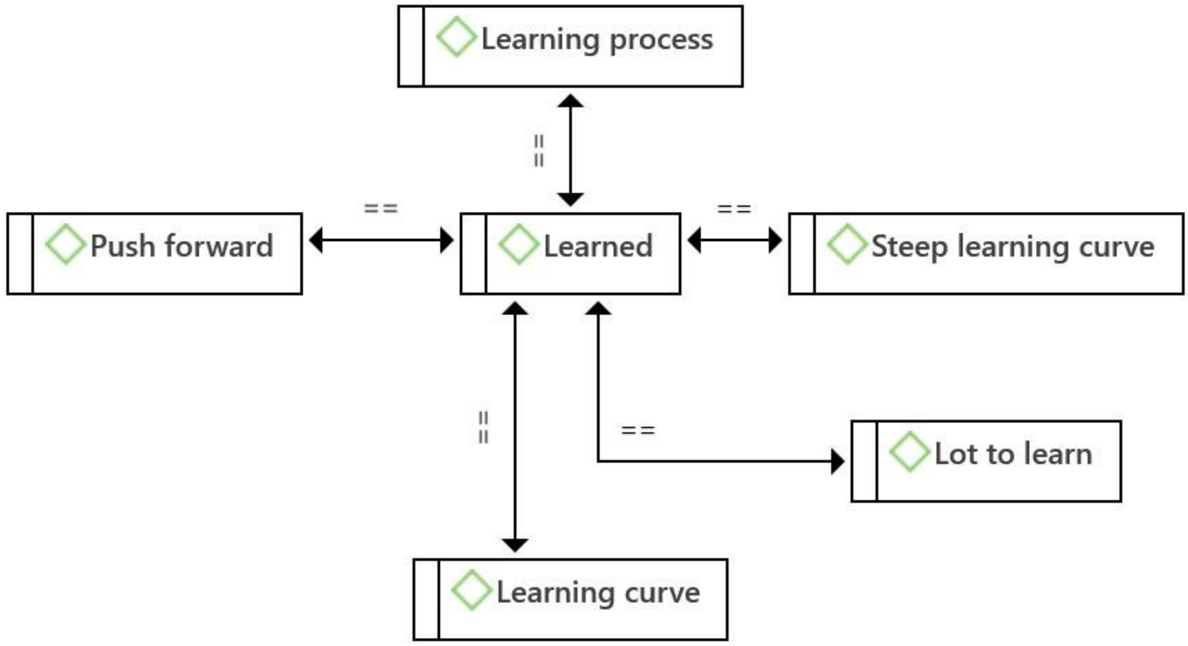
The IMFUNDO conceptual network



What was learned?

Academics were requested to respond to the question: What did you learn from the OCPD? The researcher generated seven codes from this question, clustered into the theme 'lesson learned'. Figure 2 presents the conceptual network 'lesson learned' from the OCPD. It was established that academics were exposed to various IMFUNDO tools with which they were unfamiliar when they used IMFUNDO prior to the OCPD programme. Prof Madala indicated that the OCPD prepared them to teach online. He was shown various tools he was unaware of and learned about them. Mr Maluleke mentioned that he learned much from OCPD about IMFUNDO tools' functionalities that could benefit and engage the student in online modules. Prof Adam indicated that OCPD on IMFUNDO provided the opportunity to learn and apply as they designed and developed the online modules. Mrs Zulu reported that OCPD on IMFUNDO was a learning process. Dr Madlala revealed that attending the continuous online sessions on IMFUNDO every day was a learning curve. The findings in this study were comparable to those reported by Patnaik and Gachago (2020) on OCPD on the use of LMS. These authors found that the Centre for Innovative Educational Technology delivered webinars that assisted the entire university. It was found that academics welcomed the IMFUNDO OCPD as it exposed them to the current use of technology to enhance teaching and learning. Dr Mokoena emphasised that academics should embrace this opportunity as technology will continue to develop further. They needed to push forward to stay relevant. The OCPD assisted the academics as they learned to upload materials to this system, set up meetings and hold online class (Sumer et al., 2021).

Figure 2:
The conceptual network of lessons learned from the OCPD



.

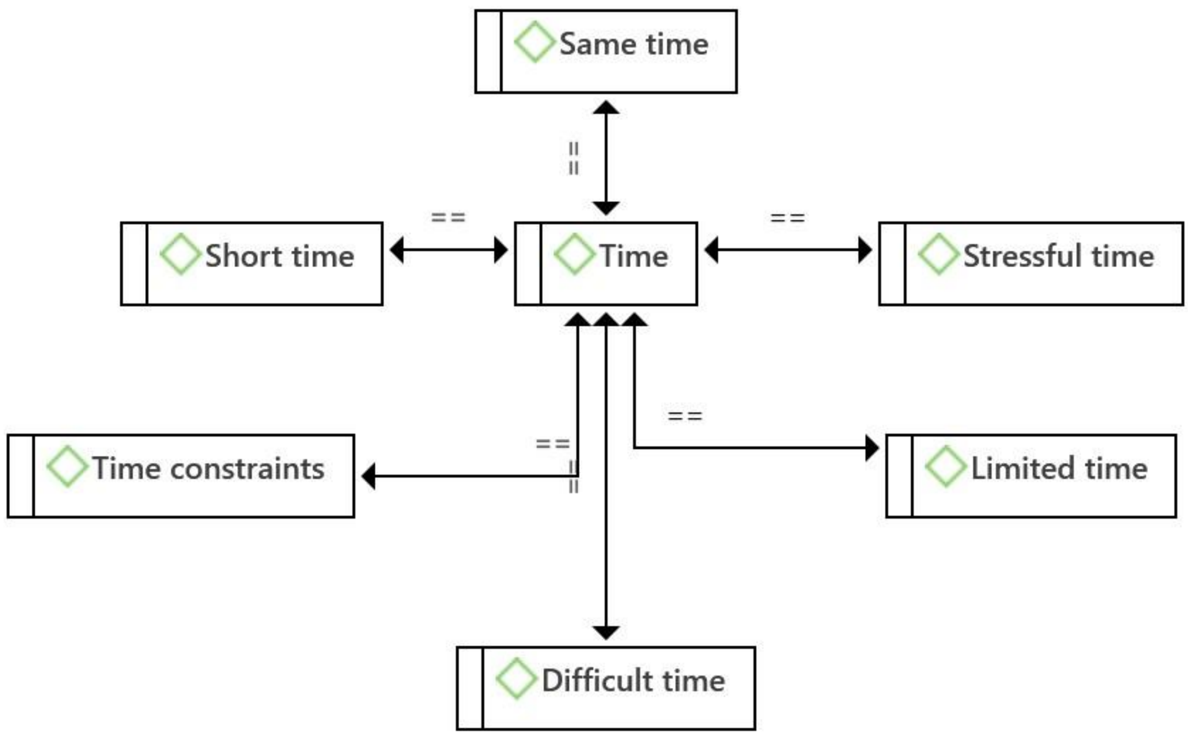
Time

Academics were requested to respond to the question: How will you evaluate the time given to prepare the learning design of your online modules on IMFUNDO? The researcher created seven codes from this question, grouped into the theme 'Time'. Figure 3 shows the conceptual network of lessons learned regarding time allocated for learning the design of online modules on IMFUNDO. It was discovered that the University allocated academics three months to design and develop their online module on IMFUNDO. The IDs were responsible for this task as they worked closely with the subject matter experts. Dr Mooi revealed that he attended all of the online sessions. He made time for it because he believed the time was allocated to prepare his modules on IMFUNDO. As academics, they needed to make positive or constructive use of the available time. Literature indicates that to become digitally literate, academics should evolve into new roles and acquire new skills and competencies that go beyond basic technical proficiency (Evans et al., 2020).

It was discovered that academics deemed three months for professional development as insufficient. However, they had to make the best of the time given. During the empowerment sessions, they were expected to plan, design and develop simultaneously. Thereafter they had to implement and evaluate their online modules. Mr Botha indicated that they had to execute the design and development with limited time allocated, ensuring that their online modules were ready for implementation. Mrs Hlaba reported that the time was too little to get the full value of IMFUNDO. Ms Ndlovu also mentioned that the timelines were very short. Prof Madlala indicated that the IMFUNDO OCPD was provided, but it was hectic. Evans et al. (2020) also referred to the limited time for professional development as these researchers found that to support academics in transforming their pedagogical approaches, once-off empowerments and seminars were insufficient. Furthermore, some academics experienced time constraints during this process as it was a difficult and stressful time in their career. Mr Maluleke indicated that this was a challenging time. However, the work had to be completed, and he had to produce interactive online modules on IMFUNDO. Dr Mtshali reported that it was an extremely stressful time initially, but as time went on, she felt more confident in using the IMFUNDO platform. Ms Coetzer said that it was time-consuming to do all of the design within a short time.

Figure 3:

The conceptual network of lessons learned regarding time allocated for learning design of online modules on IMFUNDO



Support

Academics were requested to indicate the support they received regarding designing, developing and implementing their online module. The researcher created nine codes from their responses in this regard, grouped into the theme 'support'. Figure 4 illustrates the conceptual network of the support provided to academics during the OCPD.

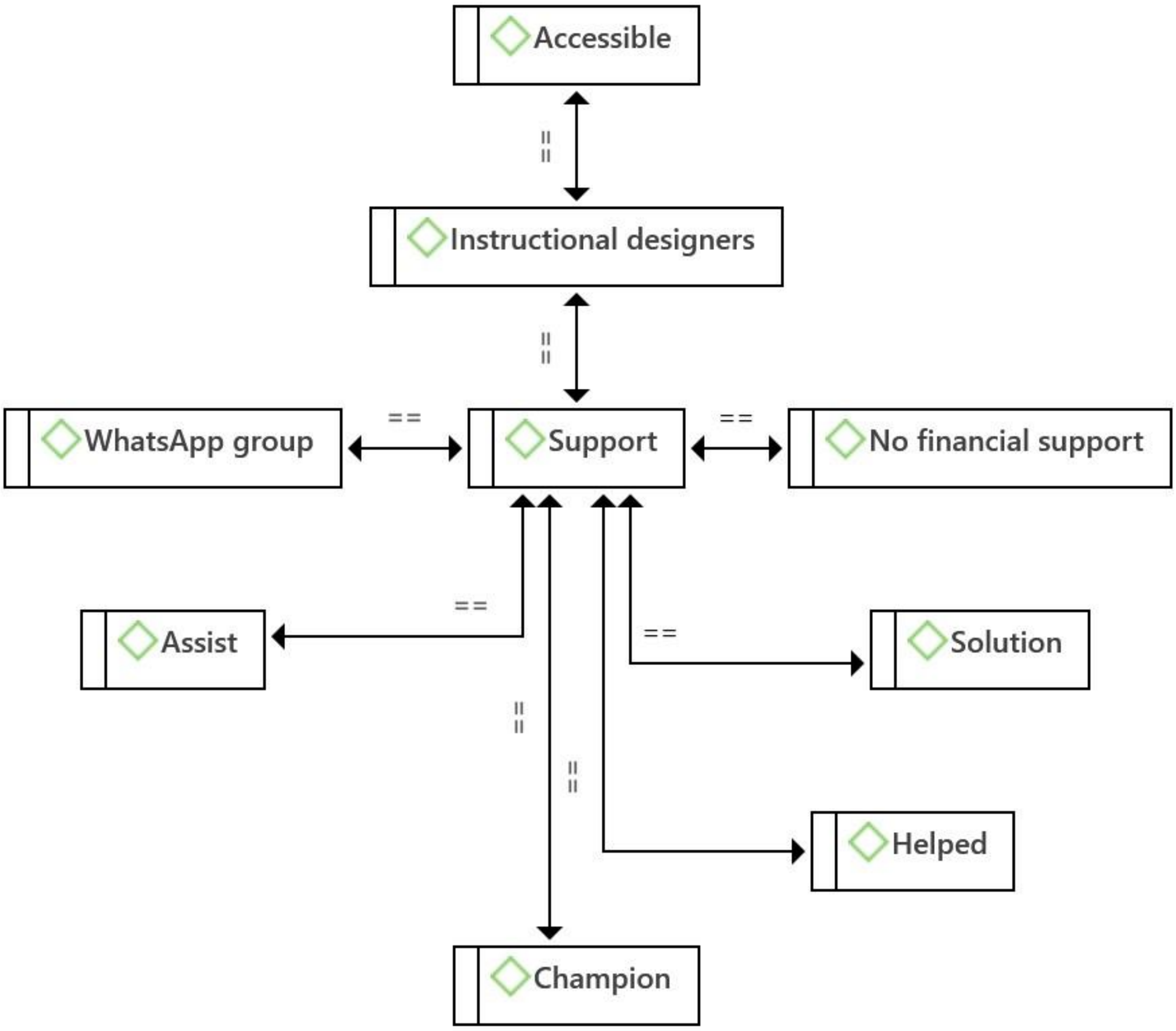
The findings revealed that academics received substantial support during the OCPD of the IMFUNDO modules. Academics commended the support from the University, Faculty ID, eChampions and other academics. Prof Adam indicated that the support from the University was excellent, and Dr Mooi emphasised receiving exceptional support regarding online teaching. These findings were supported by

Deliwe (2021), who reported that the champion in e-learning, advised other academics on how to use MOODLE more effectively and with a better understanding of its capability. It was found that continuous support assisted in reducing academics' stress levels. Mrs Mokoena said that with more OCPD and continuous support, the stress became less and easier to manage, and she could execute most of the IMFUNDO functions. Sumer et al. (2021) supported this sentiment, indicating that training/guides on new systems assisted academics in reducing their anxiety.

It was discovered that most academics applauded the Faculty ID's support. Mrs Mafa revealed that she was pleased because she gained a lot of experience as the Faculty ID offered informative OCPD. Mrs Hlaba indicated that during the OCPD activities, the institutional IDs offered continuous support and assisted them in ensuring that their online modules were ready for implementation. It was also established that the Faculty eChampions contributed immensely during the process by providing additional support in the departments. Literature shows that e-learning champions are critical in motivating, assisting and encouraging colleagues in their particular departments (Patnaik & Gachago, 2020). Mrs Hlaba indicated that appointing certain academics to be the champions in the process worked well. Mr Botha mentioned that he was quite impressed by how the ID and eChampions handled the entire matter. Gachago et al. (2017) support this argument. They further noted that in addition to assisting colleagues, the champions also shared their expertise outside of their areas. These authors further stated that relying on a core group of interdisciplinary champions with a broad skill set aids IDs in gaining influence in the department and fostering bottom-up innovation. Ms Coetzer said that the Faculty ID and Dr Mashaba and her team of champions did their best to guide and assist staff members in a short period of time. Ms Ndlovu reported that the eChampions worked well. Research revealed that champions should have a broad knowledge and vision of their role, motivate and promote innovation, adopt multiple perspectives, and work collaboratively with people (Howell & Higgins, 1990). In another study, champions viewed themselves as motivating learning in new ways and developing a higher interest in online delivery, which grew and enhanced their expertise as academics (Dennis, McCarthy & Glassburn, 2023).

The present study findings also revealed that, during the OCPD programme, the Faculty ID applied the IMFUNDO teaching and empowerment [training] framework (ITEF) as a mechanism to support academics (Simelane-Mnisi, 2022) and endured to cover the spectrum scope of learning design. Prof Madlala indicated that the Faculty ID covered all the different levels needed to assist both lecturers and students as much as possible. Mr Malukele revealed that the OCPD on IMFUNDO helped him significantly build his modules. It was discovered that, whenever academics encountered a problem, a solution was provided, and the Faculty ID was easy to contact. Ms Zulu indicated that if she experienced problems, there was a direct solution. Dr Madlala mentioned that, if academics did not understand something, the ID was accessible and provided answers. The findings further revealed that the Faculty WhatsApp community of practice group also provided immediate solutions to the faculty academics' questions and problems. Prof Adam felt they were very fortunate because the Faculty ID started the Faculty WhatsApp community of practice group prior to the online empowerment. The platform became handy as it was used effectively to solve the challenges encountered while working alone. When academics experience support, they develop a belief in change, which inspires them to put in extra effort and improve society (Law, 2022).

Figure 4:
The conceptual network of the support provided to academics during the OCPD.



CONCLUSION

Through the OCPD programme, academics learned to use LMS digital resources to develop learning activities that encouraged participation, interaction, and engagement among students in a digital environment. Since an ID was knowledgeable in the field, it was imperative to provide necessary support to academics so that they could create their online modules using appropriate ID principles and relevant LMS tools and ensure constructive alignment as stipulated in the curriculum. The OCPD conducted webinars using the ITEF contributed to the improvement of academics' digital competencies as they had to create their IMFUNDO modules on their own. This was observed when academics.

In light of the study's findings, it is evident that the academics perceived OCPD using to IMFUNDO as successful. Through the OCPD programme, academics were taught to adopt LMS digital tools that foster student engagement in an online environment by creating learning activities that foster engagement, interaction, and participation. Furthermore, academics were provided with an LMS template that was tailored to the module offered; a one-size-fits-all template proved ineffective. It is for this reason that academics adopted transformative learning and were able to design and develop their material. It may be concluded from this study that the academics learned new and innovative ways of teaching online using IMFUNDO. It is, therefore, critical that for any OCPD to be successful, institutions provide time for academics to attend professional development, as academics often indicate that too much workload is a hindrance to their empowerment. Another critical aspect that came out of this study was the support that was provided from the University, Faculty ID, eChampions, and other academics in ensuring that the modules were developed to meet the university standard and the quality of online modules. It is seen from this study that academics were exposed to various IMFUNDO tools that were new to them but which they could use through the guidance and support offered by the Faculty ID and eChampions. The OCPD is essential for maintaining value-added output at the workplace and ensuring survival in the current rapid evolution and transformative education driven by technology.

RECOMMENDATIONS

Institutions of higher learning must continue to present OCPD in the form of webinars to attract more academics. It is recommended that further studies be conducted on students' perceptions of implementing the IMFUNDO modules developed in this study. A further study can be conducted with a larger sample. A mixed-method approach study could also be conducted in a similar context in higher education.

REFERENCES

Aliyu, J., Osman, S., Daud, M.F. & Kumar, J.A. (2021) Mathematics teachers' pedagogy through technology: A systematic literature review. *International Journal of Learning, Teaching and Educational Research* 20(1) pp.323-341, https://doi.org/10.26803/ijlter.20.1.18

Al-Naabi, I. (2023) Did they transform their teaching practices? A case study on evaluating professional development webinars offered to language teachers during COVID-19. *International Journal of Higher Education* 12(1), https://doi.org/10.5430/ijhe.v12n1p36

Amado-Salvatierra, H.R., Rizzardini, R.H. & Chan, M.M. (2020, September) The rise of webinars: thousands of learners looking for professional development. A practical case study. In *2020 IEEE Learning with MOOCS (LWMOOCS)* pp.191-194, https://doi.org/10.1109/LWMOOCS50143.2020.9234365

Budiantara, A., Mustaji, M. & Setyowati, R.R.N. (2023) Development of teaching materials based learning management system "Sifajargoro" to foster attitudes of responsibility and student learning outcomes in the subjects of civics fifth grade elementary school students. Edunesia: *Jurnal Ilmiah Pendidikan* 4(1) pp.294-311, https://doi.org/10.51276/edu.v4i1.346

Buxton, E.C., Burns, E.C. & De Muth, J.E. (2012) Professional development webinars for pharmacists. *American journal of pharmaceutical education* 76(8) pp.1-7, https://doi.org/10.5688/ajpe768155

Cho, H.J., Zhao, K., Lee, C.R., Runshe, D. & Krousgrill, C. (2021) Active learning through flipped classroom in mechanical engineering: improving students' perception of learning and performance. *International Journal of STEM Education* 8(1) pp.1-13.

Cohen, L., Manion, L. & Morrison, K. (2018) *Research methods in education* (8th ed.). London, Routledge.

Creswell, J.W. (2014) *Qualitative, quantitative and mixed methods approaches*. Thousand Oaks, CA: SAGE.

Creswell, J.W. & Creswell, J.D. (2018) *Research design: Qualitative, quantitative and mixed methods approaches* (5th ed.). London, SAGE.

Deliwe, A.P. (2021, July) Factors essential for successful and sustainable e-learning. In *7th International Conference on Higher Education Advances (HEAd'21)* Editorial. Universitat Politècnica de València, pp.941-948.

Dennis, S.R., McCarthy, K.M. & Glassburn, S.L. (2023) Grievers, skeptics, pragmatists, converts, and champions: Social work educators' transition to online teaching. *Journal of Social Work Education* 59(2) pp.544-557, https://doi.org/10.1080/10437797.2021.2019644

Evans, J.C., Yip, H., Chan, K., Armatas, C. & Tse, A. (2020) Blended learning in higher education: professional development in a Hong Kong university. *Higher Education Research & Development* 39(4) pp.643-656, https://doi.org/10.1080/07294360.2019.1685943

Gachago, D., Morkel, J., Hitge, L., Van Zyl, I. & Ivala, E. (2017) Developing eLearning champions: a design thinking approach. *International Journal of Educational Technology in Higher Education* 14 pp.1-14.

Gegenfurtner, A. & Ebner, C. (2019) Webinars in higher education and professional training: A meta-analysis and systematic review of randomised controlled trials. *Educational Research Review* 28(100293) pp1-19, https://doi.org/10.1016/j.edurev.2019.100293

Howell, J.M. & Higgins, C.A. (1990) Champions of change: Identifying, understanding, and supporting champions of technological innovations. *Organisational dynamics* 19(1) pp.40-55, https://doi.org/10.1016/0090-2616(90)90047-S

Law, M.Y. (2022) A review of curriculum change and innovation for higher education. *Journal of Education and Training Studies* 10(2) pp.16-23, https://doi.org/10.11114/jets.v10i2.5448

Li, M. & Yu, Z. (2022) Teachers' satisfaction, role, and digital literacy during the COVID-19 pandemic. *Sustainability* 14(3) pp.1-19, https://doi.org/10.3390/su14031121

Patnaik, S. & Gachago, D. (2020) November. Supporting departmental innovation in eLearning during COVID-19 through eLearning champions. In *2020 IFEES World Engineering Education Forum-Global Engineering Deans Council (WEEF-GEDC)* pp.1-4. IEEE.

Power, R. (2019) What do instructional designers do? https://www.powerlearningsolutions.com/blog/what-do-instructional-designers-do (Accessed 29 January 2023).

Saldaña, J. (2021) *The coding manual for qualitative researchers. The Coding Manual for Qualitative Researchers*. Thousand Oaks, CA: SAGE.

Shahzad, K., Khan, S.A., Javed, Y. & Iqbal, A. (2023) E-Learning for continuing professional development of university librarians: A systematic review. *Sustainability* 15(1) pp.1-18, https://doi.org/10.3390/su15010849

Simelane-Mnisi, S. (2022a) Effectiveness of quality review of the online modules used during emergency multi-modal teaching and learning in higher education. *Public Administration and Development Alternatives (IPADA)* pp.289-297.

Simelane-Mnisi, S. (2022b, October) Effectiveness of the capacity development programme on the creation of IMFUNDO Modules by the university teachers. *In European Conference on e-Learning* 21(1) pp.373-381.

Simelane-Mnisi, S. & Mji, A. (2020) Preparing lecturers for remote teaching and flexible learning during COVID-19 pandemic. In *13 Annual International Conference on education Research Innovation (ICERI2020) Virtual Conference*. Seville, Spain, pp.9111-9120.

Simelane-Mnisi, S. & Mokgalaka-Fleischmann, N. (2022) Training framework to enhance digital skills and pedagogy of chemistry teachers to use IMFUNDO. *New updates in e-learning* pp.33-50.

Sumer, M. Douglas, T. & Sim, K.N. (2021) Academic development through a pandemic crisis: Lessons learnt from three cases incorporating technical, pedagogical and social support. *Journal of University Teaching & Learning Practice* 18(3) pp.1-14.

Tawfik, A.A., Gatewood, J., Gish-Lieberman, J.J. & Hampton, A.J. (2022) Toward a definition of learning experience design. *Technology, Knowledge and Learning* 27 pp.309-334.

Van, L.H.H. & Hiep, N.X. (2020) Motivating freshmen in learning vocabulary with innovative interactive whiteboard activities, harmony in diversity. In *Proceedings of the Transcultural Society, Thailand, TESOL* pp.172-196.

The use of M-learning to foster the development of self-regulated learning in university students: A systematic review[6]

Ishmael Nyirenda, Rhodes University, South Africa

Clement Simuja, Rhodes University, South Africa

ABSTRACT

The rapid development of mobile technologies and their price decrease have enabled mobile devices to become ubiquitous. Both lecturers and students are integrating mobile technologies into teaching and learning. The continuous global innovation in emerging mobile technologies and their ever-increasing overlap with the lives of students and lecturers in Higher Education Institutions (HEIs) have thrust M-learning and self-regulated learning into prominence. Accordingly, this review analyses conference proceedings and national and international journals on the potential of M-learning for fostering self-regulated learning. To select relevant sources, a systematic literature review approach was employed. This study fills gaps in existing literature and investigates how mobile devices might enhance self-regulated learning among university students. It also signals future research directions and offers implications for researchers and practitioners in HEIs.

Keywords: self-regulated learning (SRL), mobile learning, higher education institutions, mobile devices

INTRODUCTION

Self-regulated learning is undoubtedly essential at the university level. This is not only because students are expected to manage and control their own learning (Lee, Watson & Watson, 2019), but also as they must develop these skills to gain knowledge in their specific field of study (Waluyo, 2018). Research indicates that one major cause of high dropout and failure rates among university students is their lack of self-regulated control over the learning process (Jansen et al., 2020; Sletten, 2017; Van der Veen & Peetsma, 2009). The value of aiding students in enhancing their self-regulated learning (SRL) abilities cannot be understated. The concept of SRL emerged as a research focal point in the educational psychology field during the 1980s. The growing interest in this area was due to its implications for student engagement and efficacy in learning tasks (Zimmerman & Schunk, 2011). Since then, the importance of SRL has further been validated through continuous research emphasis. Investigative forays into this subject resulted in exploring the influence of various social elements on students' self-regulated learning capabilities, offering a comprehensive understanding of the complex dynamics at play (Hadwin et al., 2011; Zimmerman, 2002)

[6] Date of Submission: 25 January 2023

Date of Review Outcome: 12 June 2023

Date of Acceptance: 20 August 2023

Self-Regulated Learning (SRL) is defined by Zimmerman (1986) as the degree to which learners generate ideas, feelings, and behaviours to achieve their learning objectives. This involves engaging intellectually, motivationally, and behaviorally in their learning processes. Following on from this, Zimmerman (2002) suggested that SRL processes incorporate self-directed activities and beliefs in self, thus enabling learners to transform their mental abilities into academic competencies. Usher and Pajares (2008) further expound the definition of SRL, seeing it as a metacognitive process that empowers students to expand their thinking. This happens when they critically analyze and evaluate the consequences of their choices, hence finding alternate pathways to academic success. From these definitions, it suggests a clear link between SRL and the development of learning processes that produce thoughts and behaviors, thereby shaping how individuals approach tasks to reach their objectives. Various studies suggest that university students can acquire SRL skills with appropriate support mechanisms such as direct instruction, modelling, practice (both guided and autonomous), reflection, self-observation, and social backup (Anand, 2015; Palalas & Wark, 2020; Van Nguyen et al., 2020; Yot-Domínguez & Marcelo, 2017).

Strategies are often suggested to help university students manage their learning (SRL). However, Anand (2015) pointed out a main issue with most of these approaches is that they are not easy to fit into a student's busy schedule. This shows the need for SRL methods that students can easily implement. Anand (2015) recommends using mobile devices to support SRL. This suggestion could fit well with students' busy lives and offer a practical solution. The literature indicates that mobile devices have the potential to serve as learning tools, as suggested by Anand (2015) and corroborated by Anshari et al. (2017), Ariel & Elishar-Malka (2019), Dalvi-Esfahani (2020), and Van Nguyen et al. (2015). Hartley et al. (2020) also associated the use of mobile devices, exemplified through multitasking during study, with improved resource management, an important competence in a learning environment. This underscores the potential for interventions that guide students towards more effective study strategies, leading to better academic outcomes, as proposed by Hartley et al. (2020). Importantly, a link has been established between mobile learning (M-Learning) and self-regulated learning (SRL) by preceding research such as that by Van Nguyen et al. (2015) and Yot-Domnguez, Marcelo (2017). M-Learning is defined by Pinkwart et al. (2003: 385) as a 'a type of learning that uses mobile devices to support learning'. This covers a range of devices including, but not limited to, Smartphones, Laptops, Tablets, Smartwatches, Hotspots, and even Mobile gaming consoles and many more (Busse et al., 2019). In an era where mobile technology is rapidly advancing, this paper aims to offer an in-depth systematic review of prior research, thereby enhancing understanding of how mobile learning (M-learning) can enable the promotion of self-regulated learning amongst higher education (HE) students. Understanding this is crucial as self-regulation in learning is a key skill for success in, HE and beyond. This paper presents the guiding methodological framework in place, followed by a delineation of the search parameters, study selection, and inclusion criteria. The paper ultimately culminates with the findings from the examined literature, with subsequent recommendations and a conclusion.

This paper aims to provide a comprehensive systematic review of previous research in order to deepen the understanding of the ways in which mobile learning (M-learning) can facilitate the development of self-regulated learning among students in higher education (HE).

RESEARCH QUESTION

What are the educational discipline areas, levels, and contexts in which M-learning is used to foster the development of self-regulated learning in university students?

METHODOLOGICAL FRAMEWORK

The objective of this study is to conduct a comprehensive systematic literature review on the use of M-Learning in promoting Self-Regulated Learning (SRL) in university students. The research question was systematically addressed through a meticulous review of relevant past studies. This approach involved the careful selection, identification, and synthesis of primary research papers. The authors employed a systematic, clear, and reproducible technique in this study that serves two main purposes: (1) to identify and select pertinent past research; and (2) to analyze and synthesize the obtained data from the selected papers. This strategy rendered a credible representation of reviewed journal articles because of the rigorous method and unbiased synthesis of the literature employed (Gopalakrishnan & Ganeshkumar, 2013; Onwuegbuzie & Frels, 2016). Hence, the goal is not only to showcase the application of M-learning in fostering SRL but also to contribute to the accumulation of credible, unbiased academic resources on the subject.

Search criteria

Search criteria were defined by three subtopic areas: search strategy, study selection and inclusion criterion, and analysis framework.

Search strategy

A systematic search for relevant studies was done utilising reputable electronic databases, including Springer, Taylor and Francis Online, Google Scholar, Science Direct, and Web of Science Core Collection, and Scopus in order to find the research that met the selection criteria. The following search terms were used: the use of M-learning by a university student and SRL among university students. In addition, phrases including combinations of one M-learning and self-regulated learning keyword (e.g., 'mobile' AND 'self-regulated*') were employed to find relevant primary studies using electronic databases.

Study selection and inclusion criteria

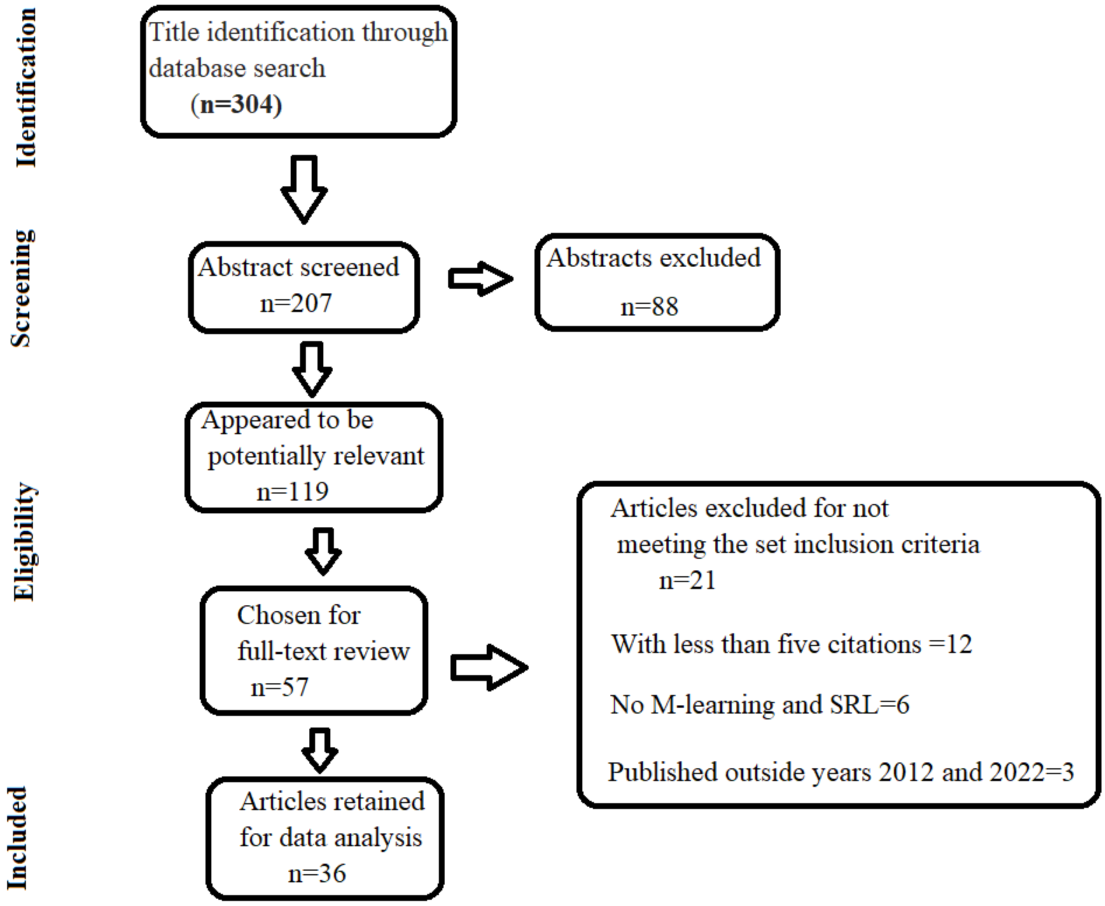
The papers had to meet the following selection criteria that were developed for the literature review in order to be included in the current study:

a) Journals and peer-reviewed publications are required to focus on M-learning and SRL
b) The article was published in a peer-reviewed English-language journal
c) The paper must be published between the years 2012 and 2022 in indexed, peer-reviewed, national, and international journals
d) The research was conducted within formal education settings
e) The article should have a minimum of five citations.

To identify search strategies and inclusion criteria, the authors in this paper individually examined two of the four data sets. Following the first sorting of the titles returned by the keyword search, a subset of the abstracts was selected for further evaluation. The remaining abstracts of publications were then divided into three categories: (1) keep for a comprehensive examination, (2) reject outright, or (3) pend rejection for reconsideration. The authors classified the findings based on abstract analyses and determined to which category each article belonged.

Through a keyword search, 304 journal articles were found. Of these, 119 seemed potentially fitting for the study. The first author subdivided these 119 articles into two categories: 81 were named '*Selected for Further Review*', and 38 were '*Possible Rejects that Require Reconsideration*'. During the first phase, 13 articles from the 'Possible Rejects' category were preserved for full-text review. Also, 57 articles were chosen from both categories for an extensive text review. The main features: inclusion criteria, and methodological soundness like article cohesion between the research question, methods, tools, and findings, were used to assess a subset of these papers. The second author reviewed the findings in each article. After careful evaluation, 36 articles were set aside for data analysis, marked with an asterisk in the reference section. Figure 1 summarizes the selection process of the 36 articles involved in the data analysis.

Figure 1:
Selection of relevant peer reviewed journal articles



Results of the reviewed literature

The review of the previous research yielded some key elements in the study of SRL and Mobile Learning. These include students' perceptions of using M-learning to foster self-regulated learning; discipline areas, level of study and educational contexts in which M-learning is used to promote self-regulated learning; types of mobile devices used to promote the development of SRL in university students and different ways on how M-learning is used to foster self-regulated learning among university students. Table 1 present the countries where these studies were conducted.

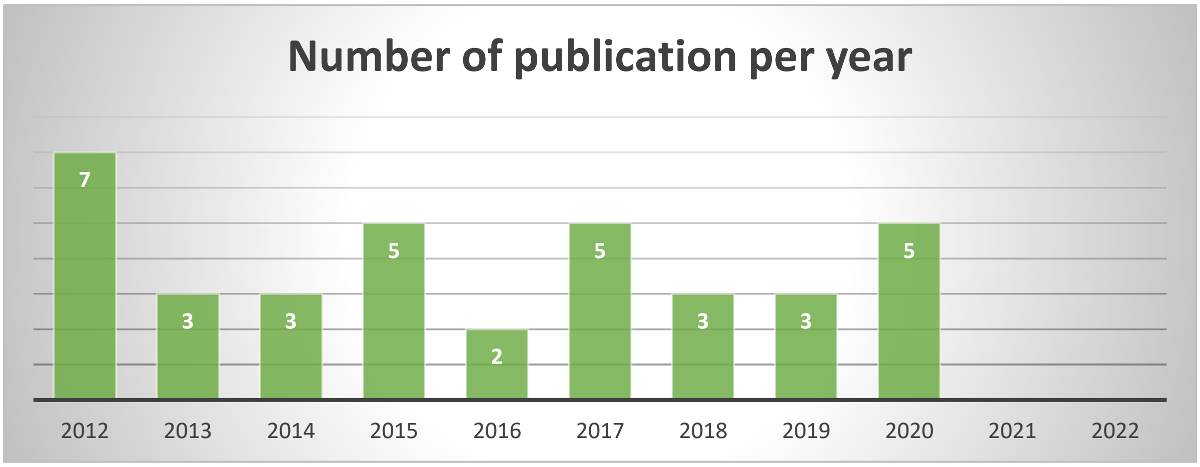
The review of previous research on Self-Regulated Learning (SRL) and Mobile Learning (M-learning) revealed several key elements. These elements included students' perceptions on using M-learning to foster SRL; the various academic fields, study levels, and educational contexts where M-learning is used; the specific mobile devices employed to enhance SRL among university students; and the diverse methods of utilizing M-learning to foster SRL among university students. Table 1 presents the countries where these studies were conducted.

Table 1:
Research Sites of the Studies (N = 36)

Country	N	Studies	Number of citations
United States	7	Dabbagh & Kitsantas, 2012; Gikas, & Grant, 2013, Wei et al 2012; Elhai, et al, 2018, Ames, 2013; Archbold Hufty Alegría et al 2014; Azevedo et al 2019,	2462, 2179, 246, 197,131, 59,33
Australia	2	Lee, 2013; Falloon, 2017	183,59
Singapore	1	Sha et al 2012,	19
Japan	1	Kondo et al 2012	177
New Zealand	1	Goh et al 2012,	110
Iran	2	Taleb, 2015; Pourrazavi, 2014	53, 101
Canada	3	Zare Bidaki et al, Ko, 2015, 2013; Boruff, & Storie, 2014,	34, 127,364
Netherlands	3	Jansen et al 2020, Tabuenca, et al 2015; Van Deursen et al, 2015	151, 244, 1090
South Korea	1	Cho, & Heron, 2015	302
Oman and United Arab Emirates	1	Al-Emran et al 2016	673
Turkey	1	Gökçearslan et al 2016	380
Germany	1	Yun et al, 2017	16
Spain	2	Alonso-Mencía et al, 2020, Yot-Domínguez, & Marcelo, 2017	51,153
Norway	1	Jeno, 2017	138
Brazil	1	Felisoni, & Godoi, 2018	209
Thailand	1	Waluyo, 2018	5
Taiwan	1	Chien, 2019	1
Malaysia	1	Albelbisi, 2019	30
Israel	1	Ariel, & Elishar-Malka, 2019	28
Indonesia,	1	Hanif, 2020	6
Brunei	1	Anshari el tal, 2017	443
China	1	Xiangming & Song, 2018	68
Sweden	1	Viberg et al. 2020	5

Figure 2 shows the number of publications in each year between 2012 and 2020. These are the articles that have been reviewed in this paper. Most papers are from 2012.

Figure 2:
Number of publications per year



Students' perception of using M-learning to foster self-regulated learning.
As one of the recent technologies in the education sector, M-learning has provided numerous exciting possibilities in the educational sector. It has made learning available regardless of location or time zones in higher education (Al-Emran & Shaalan, 2015). Studies show beneficial outcomes resulting from the use of mobile devices to enhance the educational process (Cavus et al., 2020; Patil et al., 2016; Taleb et al., 2015). For instance, Patil et al. (2016) carried out a study examining the attitudes and perceptions of medical undergraduates towards m-learning. They surveyed 90 third-year medical students from a tertiary healthcare facility, Nashik University, Department of Community Medicine. Utilizing a pre-approved questionnaire, the study explored students' learning methods to ascertain whether their learning approach was deep or superficial. Results indicated that students generally had a positive demeanor towards m-learning, deeming it an important learning tool. Despite this positivity, these medical students failed to fully utilize m-learning when given the chance.

Similarly, Hanif (2020) explored university students' SRL levels and their impact on m-learning adoption attitudes specifically for English learning. His study revealed that the majority of students considered m-learning as a valuable tool for education, as evident from their self-regulated m-learning usage. Further elaborating on the benefits of m-learning, a study conducted by Al-Emran et al. (2016) suggested m-learning as a practical method for university students to independently manage their learning process.

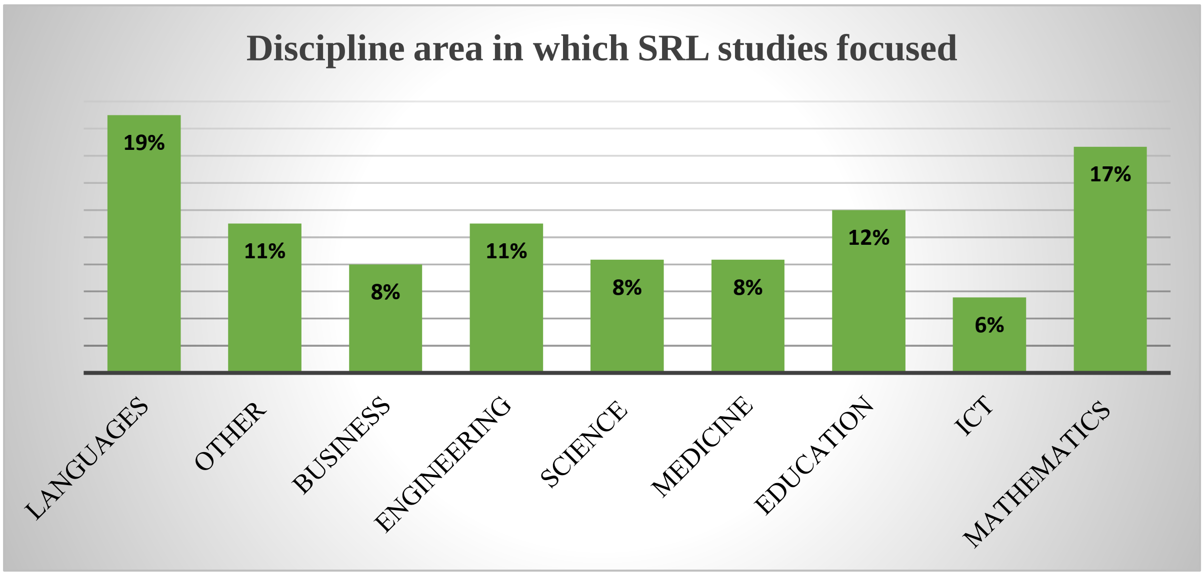
Furthermore, Yot-Domnguez and Marcelo (2017) conducted a study on how university students use digital technologies for SRL. Despite the frequent utilisation of digital technology by students, the study reveals that it is not often directed towards self-regulation of their learning. A significant proportion of students have not been trained or properly engaged in applying mobile technologies in their academic process. Consequently, they sporadically employ it to enhance their SRL skills. Thus, the study suggests the importance of informing students about the value of technologies often used in mobile learning and promoting their integration into the learning process. This will result in the effective self-regulation of students' learning (Domnguez, & Marcelo, 2017). Therefore, it is necessary to develop deliberate strategies that enable students to utilize mobile technology to promote their self-regulated learning.

Discipline areas of study
The data in Figure 3 demonstrate that among the reviewed papers in this study, seven focused on language studies, accounting for 19.2 %, followed by mathematics (n=6; 16.7%). Information Communication Technology (ICT) recorded the least focus with only two papers (5.6%). Both theoretically and experimentally, these papers demonstrate how SRL theories and methods could assist in

understanding M-learning processes. They indicate that student motivation majorly determines their engagement level in M-learning activities, encompassing variables like metacognition, motivation, and behaviour. In addition, the studies in Medicine, Mathematics, Engineering, and Science discuss how M-learning influence students' motivation, cooperation, and perspectives on information-seeking and sharing. The idea that M-learning can help students boost their skills in specific areas while promoting SRL is assessed. Furthermore, the language studies utilized various tools to support independent learning by students. They revealed that leveraging these technological tools inspired students to learn independently, visible in factors like time spent on learning activities, the satisfaction gained from the activities, and self-assessed achievement. SRL was evident in aspects of goal specificity and personalized learning task development.

Figure 3:
Discipline area which SRL studies focused on

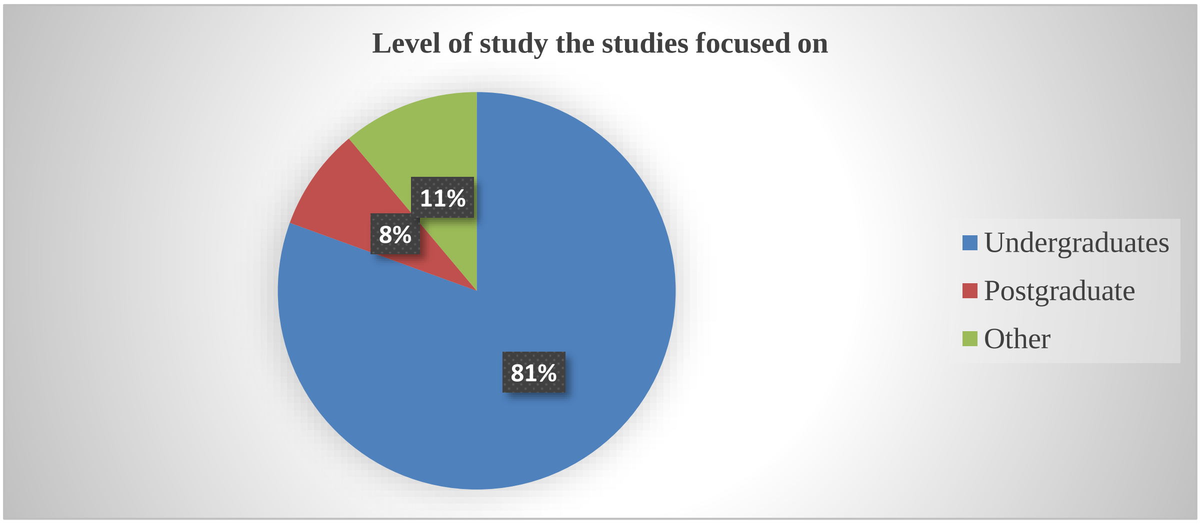
,



Level of study on which the study focused

In Figure 4, a significant majority of the studies, 81% (n=29), involved undergraduate students. This was followed by an unspecified group of students representing 11% (n=4), and postgraduate students at 8% (n=3). Whilst the utilization of mobile technologies is commonplace amongst these students, these tools are not typically applied in managing their own learning processes. Frequently employed technologies within universities, as identified by the studies, encompass instant messaging, mobile applications, and internet research. Notably, the most commonly used self-regulation learning techniques are associated with social support. However, the extent and frequency of using these techniques are subject to variation among students. More specifically, postgraduate students tend to deploy them more regularly compared to their undergraduate counterparts.

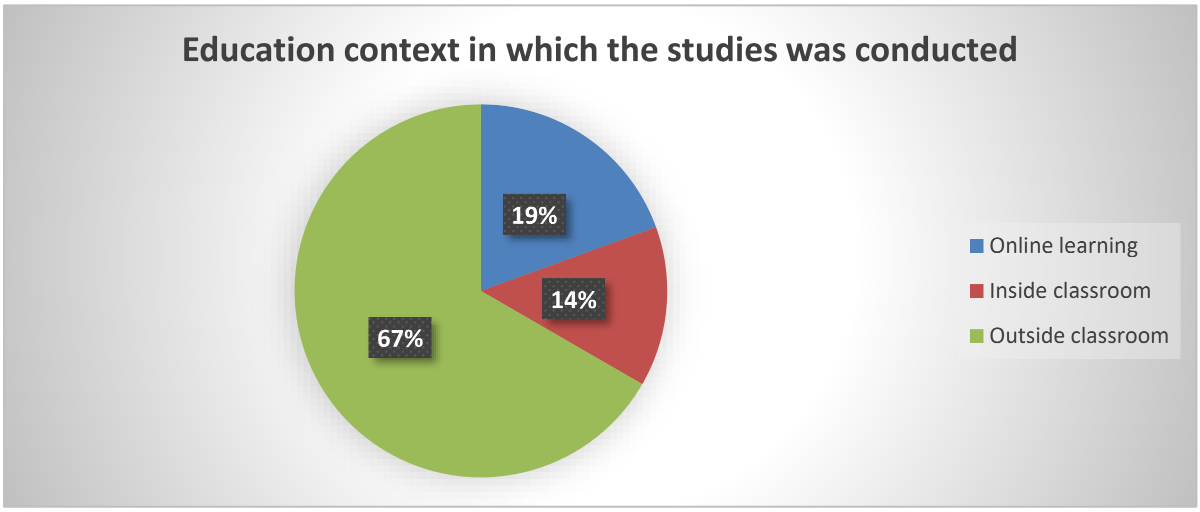
Figure 4:
Level of Study the studies focused on



Education context in which the studies were conducted

The studies in the reviewed literature involved students in three educational contexts: inside the classroom, outside the classroom, and online learning, as shown in Figure 5.

Figure 5:
Discipline area in which studies focused on

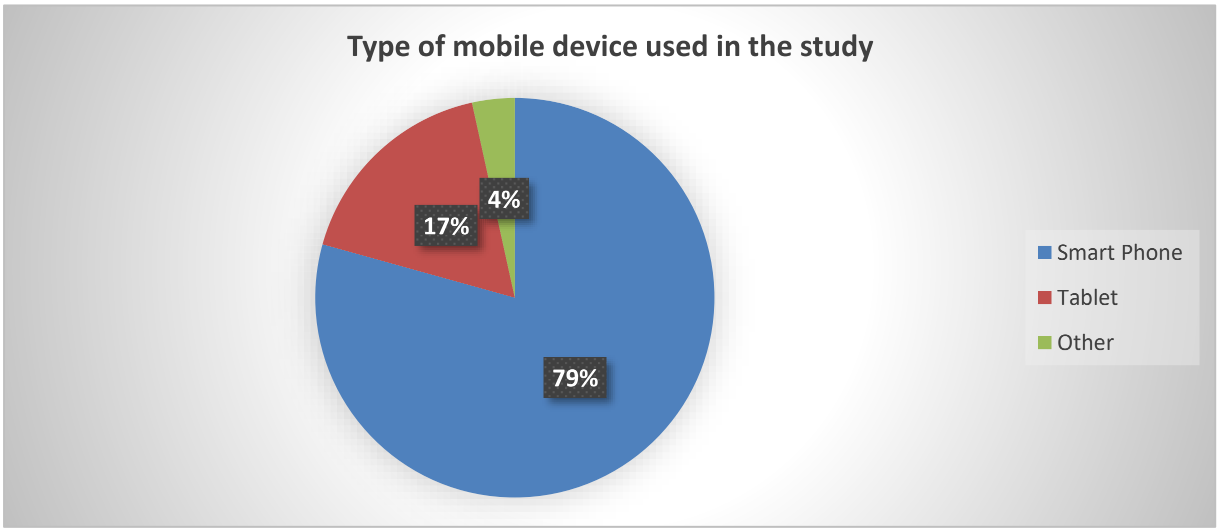


Most of the studies (n=24; 67%) focused on using mobile learning outside of the classroom context, followed by a smaller portion (n=7, 19%) focused on online learning contexts. A mere five studies (14%) focused on inside a classroom setting. The studies on online learning homed in on behaviours that promote SRL in a mobile learning environment. The results indicated that the use of social media and mobile devices facilitated opportunities for interaction and collaboration. Moreover, these tools allowed students to actively participate in content creation and communication. Mobile devices were used extensively in all aforementioned disciplines (Figure 3), both inside and outside the classroom, to enable students to manage and control their learning effectively. Furthermore, it was found that these devices also supported students in regulating their own learning processes (Yot-Domnguez & Marcelo 2017).

Types of mobile devices university students use to promote the development of SRL.

The reviewed studies show that the commonly used mobile device used in the studies to promote SRL is a smartphone (n=23, 79%), followed by a tablet (n=5, 17%). A smartphone is a widely used and extensively researched gadget in all the fields shown in Figure 6. Most studies focus on how students use smartphones to manage and control their learning.

Figure 6:
Type of mobile devices used in the study



The use of M-learning to foster self-regulated learning among university students

A systematic review of prior studies has divulged various methods through which M-learning can be utilized to enhance SRL. Among these, Yun et al. (2017) explored the enhancement of M-learning tools specifically designed for SRL, through the use of sensors. Their findings suggest that while training students in SRL is feasible, its real-world applicability and consistent enforcement across different contexts remain uncertain. Hence, they introduced the concept of sensor technology in SRL, proposing its integration into the design of learning companions. Concepts such as environmental learning cues, behavioural patterns, cognition signals, and motivational factors were suggested as critical sensor-recognition criteria. The aim of their proposition was to enable mobile devices to discern vital learning data, aiding students in realizing their individual potential and achieving superior learning experience.

In addition, Chin-Wen (2019) and Ren'ee et al. (2020) utilized pre-recorded short videos, including self-regulated learning (SRL) instruction and study suggestions, in their studies to augment students' SRL. They encouraged students to play these videos on their mobile devices, leveraging them as guides for the suggested study techniques. The findings from these studies illustrated that this intervention approach had a positive impact on the students' ability to complete their studies. Consequently, based on these results, it seems reasonable to suggest that aligning expectations between students and teachers regarding appropriate mobile device usage could improve the learning environment. This alignment also has the potential to facilitate learners' use of mobile devices as educational or learning tools.

Tabuenca et al. (2015) looked at graduate students taking three different online courses in their longitudinal study. Over four months, the students used their mobile devices to track their study time. The study showed concrete demonstration that recording study time benefited the learners. Moreover, the research provided valuable information about how to design mobile alerts. As suggested by the results, these alerts have the potential to motivate online students to manage their own learning more effectively.

Furthermore, various mobile applications have been utilized to promote SRL amongst a growing number of university students. For instance, Xiangming and Song (2018) used the Rain Classroom, a mobile application dedicated to English language acquisition, in their study exploring the intersection of mobile technology affordance and social consequences. The Rain Classroom comprehensively optimizes the pedagogical process. This involves distributing courseware before classes via text and voice on PowerPoint presentations, enabling real-time participant feedback during class, and facilitating interactive multi-screen interaction between students and lecture presentations. One unique feature of the Rain Classroom which further supported students in steering their learning was the automatic creation and storage of comprehensive learning data on student's mobile devices. Similar,

Kondo et al. (2012) utilized a tool called Mobile-Assisted Language Learning (MALL) in their research. MALL is technology used to support students in bettering their listening and reading scores on the Test of English for International Communication (TOEIC). The outcomes of their research showed that the MALL module boosted self-study in terms of time spent on learning, satisfaction from tasks, and self-measured accomplishment. In a related study conducted by Jeno (2017), it was found that mobile applications could help biology students learn to identify biological species faster. The study showed that using a mobile application helped students better understand the significant learning value of 'sedge identification.

Most of the research reviewed primarily in this paper focuses on utilizing Mobile Learning as a tool to enhance SRL. Other studies have delved into the role of mobile device usage, investigating how M-learning influences SRL. Moreover, certain research papers have explored the intricate relationship between M-learning, SRL, and additional variables that contribute to the growth of SRL. The outcomes of these studies are largely optimistic. Many of them indicate that M-learning significantly improves SRL and impacts other facets of learning. In summary, extensive research has investigated the link between M-learning and SRL, giving a promising outlook towards the potential of M-learning as a fundamental tool for bolstering SRL skills.

RECOMMENDATION AND CONCLUSION

The findings from the 36 studies systematically reviewed in this paper indicate that mobile learning offers significant benefits in promoting SRL. Moreover, the literature selected presents a combined view of the various factors involved in the study of M-learning and SRL. These results reveal that a noteworthy proportion of students in higher education have a positive response towards using M-learning to manage their learning strategies more effectively.

Acquiring SRL skills has the potential to aid students in higher education to surmount the multitude of challenges that arise throughout the learning process. Nevertheless, it is crucial to provide some level of instruction and training to facilitate a smooth adoption of M-learning to encourage SRL. Although providing training for self-regulated learning techniques is feasible, the clarity of their efficacy in various contexts is obscured, with minimal encouragement given. Moreover, it is essential to implement mobile technology that can bolster students' learning experience, aiding them in becoming more competent individuals with enriched learning experiences.

Nevertheless, it is important to note that students should be encouraged to learn in an environment free of pressure, viewing it as a pathway towards personal development. This involves creating environments that are free from fear and technological intimidation, particularly when designing interventions to support students in utilizing mobile devices for SRL. Implementing this involves making suitable mobile technology accessible to students. Moreover, the proposed use of mobile technology should not disrupt their learning process. Additionally, providing students with access to information that enhances their emotional and cognitive stability is crucial. Crucially, support in selecting effective learning techniques can empower students to successfully manage and regulate their learning.

This paper posits that smartphones, frequently used mobile devices, are important for promoting SRL in university students. The evidence from the reviewed literature suggests that various mobile learning strategies, such as mobile applications and pre-recorded videos, provide an effective support for SRL. Based on the findings, mobile learning could be instrumental in fostering SRL development among university students. However, it is important to note that students need suitable guidance to optimally use mobile learning for their SRL. Hence, we recommend that higher education intuitions deliberately incorporate both SRL and mobile learning into their standard curriculum. It is crucial that well-informed and tech-savvy lecturers leverage mobile learning tools to aid students in their journey towards becoming self-regulated learners.

REFERENCES

Albelbisi, N.A. (2019) The role of quality factors in supporting self-regulated learning (SRL) skills in MOOC environment. *Education and Information Technologies* 24(2) pp.1681-1698, https://doi.org/10.1007/s10639-018-09855-2

Al-Emran, M. & Salloum, S.A. (2017) Students' Attitudes Towards the Use of Mobile Technologies in e-Evaluation. *International. Journal of Interactive Mobile Technologies* 11(5) pp.195-202, https://doi.org/10.3991/ijim.v11i5.6879

Alonso-Mencía, M.E., Alario-Hoyos, C., Maldonado-Mahauad, J., Estévez-Ayres, I., Pérez-Sanagustín, M. & Delgado Kloos, C. (2020) Self-regulated learning in MOOCs: lessons learned from a literature review. *Educational Review* 72(3) pp. 319-345, https://doi.org/10.1080/00131911.2019.156620

Ames, M.G. (2013) Managing mobile multitasking: The culture of iPhones on Stanford campus. *Proceedings of the 2013 conference on Computer supported cooperative work, San Antonio, Texas, 23-27 February,* pp. 1487-1498 https://www.morganya.org/research/ames-cscw13

Anshari, M., Almunawar, M.N., Shahrill, M., Wicaksono, D.K. and Huda, M., 2017. Smartphones usage in the classrooms: Learning aid or interference? *Education and Information technologies* 22(6) pp. 3063-3079, https://link.springer.com/article/10.1007/s10639-017

Archbold Hufty Alegría, D., Boscardin, C., Poncelet, A., Mayfield, C. & Wamsley, M. (2014) Using tablets to support self-regulated learning in a longitudinal integrated clerkship. *Medical education online* 19(1) p. 23638, https://doi.org/10.3402/meo.v19.23638

Ariel, Y. & Elishar-Malka, V. (2019) Learning in the smartphone era: Viewpoints and perceptions on both sides of the lectern. *Education and Information Technologies* 24(4) pp. 2329-2340, https://doi.org/10.1007/s10639-019-09871-w

Boruff, J.T. & Storie, D. (2014) Mobile devices in medicine: a survey of how medical students, residents, and faculty use smartphones and other mobile devices to find information. *Journal of the Medical Library Association* 102(1) p.22. https://doi.org/10.3402/meo.v19.23638

Bringula, R.P., Alvarez, J.N., Evangelista, M.A. & So, R.B. (2018) Learner-interface interactions with mobile-assisted learning in mathematics: Effects on and relationship with mathematics performance. In *K-12 STEM Education: Breakthroughs in Research and Practice* pp.305-321. IGI Global.

Busse, J., Lange, A. & Schumann, M. (2019) Effects of digitalization on vocational education and training: First results of a qualitative study. *DELFI 2019*, https://doi:10.18420/delfi2019_20

Carter Jr, R.A., Rice, M., Yang, S. & Jackson, H.A. (2020) Self-regulated learning in online learning environments: strategies for remote learning. *Information and Learning Sciences,* 121(5/6) pp.321-329 https://doi.org/10.1108/ILS-04-2020-0114

Chien, C.W. (2019) Taiwanese EFL undergraduates' self-regulated learning with and without technology Innovation in Language Learning and Teaching 13(1) pp.1-16, https://doi.org/10.1080/17501229.2016.1264076

Cho, M.H. & Heron, M.L. (2015) Self-regulated learning: The role of motivation, emotion, and use of learning strategies in students' learning experiences in a self-paced online mathematics course. *Distance Education* 36(1) pp. 80-99, https://doi.org/10.1080/01587919.2015.1019963

Chu, H.C., Liu, Y.M. & Kuo, F.R. (2018) A mobile sleep-management learning system for improving students' sleeping habits by integrating a self-regulated learning strategy: randomized controlled trial. *JMIR mHealth and uHealth* 6(10) p.e11557, https://mhealth.jmir.org (Accessed 30 June 2022).

Dabbagh, N. & Kitsantas, A. (2012) Personal Learning Environments, social media, and self-regulated learning: A natural formula for connecting formal and informal learning. *The Internet and Higher Education* 15(1) pp. 3-8, https://doi:10.1016/j.iheduc.2011.06.002

Dalvi-Esfahani, M., Alaedini, Z., Nilashi, M., Samad, S., Asadi, S. & Mohammadi, M. (2020) Students' green information technology behavior: Beliefs and personality traits. *Journal of Cleaner Production 257* p.120406, https://doi.org/10.1016/j.jclepro.2020.120406

Elhai, J.D., Tiamiyu, M.F., Weeks, J.W., Levine, J.C., Picard, K.J. & Hall, B.J. (2018) Depression and emotion regulation predict objective smartphone use measured over one week. *Personality and Individual Differences* 133 pp. 21-28, http://dx.doi.org/10.1016/j.paid.2017.04.051

Felisoni, D.D. & Godoi, A.S. (2018) Cell phone usage and academic performance: An experiment. *Computers & Education* 117 pp. 175-187, http://dx.doi.org/10.1016/j.compedu.2017.10.006

Gikas, J. & Grant, M.M. (2013) Mobile computing devices in higher education: Student perspectives on learning with cellphones, smartphones & social media. *The Internet and Higher Education* 19 pp.18-26, http://dx.doi.org/10.1016/j.iheduc.2013.06.002

Goh, T.T., Seet, B.C. & Chen, N.S. (2012) The impact of persuasive SMS on students' self-regulated learning. *British Journal of Educational Technology* 43(4) pp. 624-640, http://doi:10.1111/j.1467-8535.2011. 01236.x

Gökçearslan, Ş., Mumcu, F.K., Haşlaman, T. & Çevik, Y.D. (2016) Modelling smartphone addiction: The role of smartphone usage, self-regulation, general self-efficacy and cyberloafing in university students. *Computers in Human Behavior* 63 pp.639-649, http://dx.doi.org/10.1016/j.chb.2016.05.091

Hadwin, A., Järvelä, S. & Miller, M. (2017) Self-regulation, co-regulation, and shared regulation in collaborative learning environments. In D.H. Schunk & J.A. Greene (Eds.), *Handbook of self-regulation of learning and performance* pp.83-106. Routledge.

Hanif, M. (2020) Students' Self-Regulated Learning in Iconic M-learning System in English Cross-Disciplined Program. *Anatolian Journal of Education* 5(2) pp.121-130, https://doi.org/10.29333/aje.2020.5210a

Hong, J.C., Hwang, M.Y., Chang, H.W., Tai, K.H., Kuo, Y.C. & Tsai, Y.H. (2015) Internet cognitive failure and fatigue relevant to learners' self-regulation and learning progress in English vocabulary with a calibration scheme. *Journal of Computer Assisted Learning* 31(5) pp.450-461, https://doi.org/10.1111/jcal.12103

Jansen, R.S., van Leeuwen, A., Janssen, J., Conijn, R. & Kester, L. (2020) Supporting learners' self-regulated learning in Massive Open Online Courses. *Computers & Education* 146 p.103771, https://doi.org/10.1016/j.compedu.2019.103771

Jeno, L.M., Grytnes, J.A. and Vandvik, V. (2017) The effect of a mobile-application tool on biology students' motivation and achievement in species identification: A Self-Determination Theory perspective. *Computers & Education* 107 pp.1-12, http://dx.doi.org/10.1016/j.compedu.2016.12.011 www.elsevier.com/locate/compedu

Ko, M., Yang, S., Lee, J., Heizmann, C., Jeong, J., Lee, U., Shin, D., Yatani, K., Song, J. & Chung, K.M. (2015, February) NUGU: a group-based intervention app for improving self-regulation of limiting smartphone use. In *Proceedings of the 18th ACM conference on computer supported cooperative work & social computing* pp.1235-1245, http://dx.doi.org/10.1145/2675133.2675244

Kondo, M., Ishikawa, Y., Smith, C., Sakamoto, K., Shimomura, H. & Wada, N. (2012) Mobile assisted language learning in university EFL courses in Japan: Developing attitudes and skills for self-regulated learning. *ReCALL* 24(2) pp.169-187, https://www.cambridge.org/ (Accessed 14 November 2022).

Lee, D., Watson, S.L. & Watson, W.R. (2019) Systematic literature review on self-regulated learning in massive open online courses. *Australasian Journal of Educational Technology* 35(1), https://doi.org/10.14742/ajet.3749

Lee, C.B. (2013) Exploring the relationship between intention to use mobile phone as a visualization tool and regulation of cognition. *Computers & Education* 60(1) pp.138-147, https://doi.org/10.1016/j.compedu.2012.08.003

Matto, G. & Kazungu, I. (2018) Mobile phone and chat apps usage among Malawi university students. *Research Report Series (RRS)* 2(1) pp.73-85, https://d1wqtxts1xzle7.cloudfront.net/ (Accessed 25 May 2022).

Onwuegbuzie, A.J. & Frels, R. (2016) Seven steps to a comprehensive literature review: A multimodal and cultural approach, Sage, Los Angles.

Palalas, A. & Wark, N. (2020) The relationship between mobile learning and self-regulated learning: A systematic review. *Australasian Journal of Educational Technology* 36(4) pp.151-172, https://ajet.org.au/ (Accessed 20 August 2022).

Patil, R.N., Almale, B.D., Patil, M., Gujrathi, A., Dhakne-Palwe, S., Patil, A.R. & Gosavi, S. (2016) Attitudes and perceptions of medical undergraduates towards M-learning (M-learning). *Journal of Clinical and Diagnostic Research* 10(10) p. JC06, https://doi:10.7860/JCDR/2016/20214.8682

Pourrazavi, S., Allahverdipour, H., Jafarabadi, M.A. & Matlabi, H. (2014) A socio-cognitive inquiry of excessive mobile phone use. *Asian Journal of Psychiatry* 10 pp. 84-89. https://doi.org/10.1016/j.ajp.2014.02.009

Sha, L., Looi, C.K., Chen, W. & Zhang, B.H. (2012) Understanding M-learning from the perspective of self-regulated learning. *Journal of Computer Assisted Learning* 28(4) pp.366-378.

Sletten, S.R. (2017) Investigating flipped learning: Student self-regulated learning, perceptions, and achievement in an introductory biology course. *Journal of Science Education and Technology* 26(3) pp.347-358. https://link.springer.com/ (Accessed 30 May 2022).

Tabuenca, B., Kalz, M., Drachsler, H. & Specht, M. (2015) Time will tell: The role of M-learning analytics in self-regulated learning. *Computers & Education* 89 pp.53-74, https://doi.10.1016/j.compedu.2015.08.004

Taleb, Z., Ahmadi, A. & Musavi, M. (2015) The effect of m-learning on mathematics learning. *Procedia-Social and Behavioral Sciences* 171 pp.83-89, https://doi.10.1016/j.sbspro.2015.01.092

Usher, E.L. & Pajares, F. (2008) Self-efficacy for self-regulated learning: A validation study. *Educational and Psychological Measurement* 68(3) pp.443-463, https://doi.org/10.1177/001316440730

Van der Veen, I. & Peetsma, T. (2009) The development in self-regulated learning behaviour of first-year students in the lowest level of secondary school in the Netherlands. *Learning and Individual differences* 19(1) pp.34-46, https://doi.org/10.1016/j.lindif.2008.03.001

Van Deursen, A.J., Bolle, C.L., Hegner, S.M. & Kommers, P.A. (2015) Modeling habitual and addictive smartphone behavior: The role of smartphone usage types, emotional intelligence, social stress, self-regulation, age, and gender. *Computers in Human Behavior* 45 pp.411-420. http://dx.doi.org/10.1016/j.chb.2014.12.039

Van Nguyen, H., Laohasiriwong, W., Saengsuwan, J., Thinkhamrop, B. & Wright, P. (2015) The relationships between the use of self-regulated learning strategies and depression among medical students: an accelerated prospective cohort study. *Psychology, Health & Medicine* 20(1) pp.59-70, https://doi.org/10.1080/13548506.2014.894640

Viberg, O. & Andersson, A. (2019) The role of self-regulation and structuration in mobile learning. *International Journal of Mobile and Blended Learning (IJMBL)* 11(4) pp.42-58, https://www.igi-global.com/ (Accessed 29 May 2023).

Viberg, O., Mavroudi, A. & Ma, Y. (2020, September) Supporting second language learners' development of affective self-regulated learning skills through the use and design of mobile technology. In *European Conference on Technology Enhanced Learning* pp.173-186. Springer, Cham.

Waluyo, B. (2018) Promoting self-regulated learning with formative assessment and the use of mobile app on vocabulary acquisition in Thailand. *Indonesian Journal of English Language Teaching and Applied Linguistics* 3(1) pp.105-124.

Wei, F.Y.F., Wang, Y.K. & Klausner, M. (2012) Rethinking college students' self-regulation and sustained attention: Does text messaging during class influence cognitive learning? *Communication Education* 61(3) pp.185-204.

Xiangming, L. & Song, S. (2018) Mobile technology affordance and its social implications: A case of "Rain Classroom". *British Journal of Educational Technology* 49(2) pp.276-291, https://d1wqtxts1xzle7.cloudfront.net (Accessed 30 May 2022).

Yot-Domínguez, C. & Marcelo, C. (2017) University students' self-regulated learning using digital technologies. *International Journal of Educational Technology in Higher Education* 14(1) pp.1-18, https://educationaltechnologyjournal.springeropen.com/ (Accessed 20 August 2022).

Yun, H., Fortenbacher, A. & Pinkwart, N. (2017, April) Improving a M-learning Companion for Self-regulated Learning using Sensors. In *International Conference on Computer Supported Education,* 2(1) pp.531-536, https://doi.10.5220/0006375405310536

Zare Bidaki, M., Naderi, F. & Ayati, M. (2013) Effects of M-learning on paramedical students' academic achievement and self-regulation. *Future of Medical Education Journal* 3(3) pp.24-28, https://doi.10.22038/FMEJ.2013.1524

Zimmerman, B.J. (1989) A social cognitive view of self-regulated academic learning. *Journal of Educational Psychology* 81(3) p.329.

Zimmerman, B.J. (2002) Becoming a self-regulated learner: An overview. *Theory into practice* 41(2) pp.64-70.

Zimmerman, B.J. & Schunk, D.H. (2011) *Handbook of self-regulation of learning and performance*. Routledge/Taylor & Francis Group.

Proctoring as a human substitution for online summative assessments in a comprehensive open distance e-learning institution: Opportunities and obstacles[7]

Lorette Jacobs, University of South Africa, South Africa
Siphamandla Mncube, University of South Africa, South Africa

ABSTRACT

At a comprehensive open distance e-learning (CODeL) university in South Africa, assessment practices were converted and offered online during and post COVID-19. Innovative proctoring methods were applied to secure the authenticity of online summative assessments. However, the use of such proctoring tools to ensure ethical behaviour of students during summative assessments remains questionable, as these tools are not infallible. A qualitative approach was applied to explore ways in which online proctoring tools can contribute toward ensuring authentic summative assessments. Through the application of collaborative autoethnography, the researchers obtained insight into opportunities and obstacles that may influence the effective use of online proctoring tools to support summative assessment activities. Findings indicate that students would go to great lengths to consult unauthorised material and share answers during summative assessments. Therefore, to enhance perceptions of ethical conduct in higher education, it is recommended that ethical principles are expanded through extended training and guidance with revolutionised proctoring technologies.

Keywords: proctoring tools, COVID-19, artificial intelligence, comprehensive open distance e-learning, ethical behaviour

INTRODUCTION

The advent of the COVID-19 pandemic has resulted in drastic changes in higher educational institutions. Globally, COVID-19 hastened the adoption of online learning, teaching and assessment practices (Hussein, Yusuf, Deb, Fong & Naidu, 2020). These changes have been experienced in all spheres of higher education, where social distancing and fewer human interactions influenced teaching, learning, assessment and research practices. In the circumstances, to increase student' engagement in higher education contexts, academics were encouraged to revise and move to online platforms to apply teaching and learning practices. Though a blended mode was followed by many institutions of higher learning pre COVID-19, all had to adapt to a fully online environments, inclusive of online assessments, during the pandemic. Clay (2020) explains that the role of assessment in the online environment has become even more important to shape students' behaviour and open opportunities for students to become active, engaged and independent learners. Towards supporting advanced learning, online assessments must

[7] Date of Submission: 5 February 2023

Date of Review Outcome: 12 June 2023

Date of Acceptance: 31 August 2023

illustrate authenticity to prepare students for completing tasks related to module outcomes; must be accessible to all students, irrespective of available technology tools; and be secure, to support the authentication of levels of competency (Peñalov, Corell, Abella-Garcia & Grande-de-Prado, 2020). Added to the above requirements, Holden, Norris and Kuhlmeier (2021) emphasise the importance of ensuring academic integrity as part of online assessment practices. The authors explain that values such as honesty, trust, fairness, respect and responsibility should become foundational in the execution of assessment practices.

However, Lee and Fanguy (2022) argue that where students are under pressure to perform, values such as honesty, integrity and responsibility are often difficult to maintain. Free access to online sources, varied opportunities to communicate with others or to cheat, become increasingly prominent. Towards ensuring the trustworthiness and integrity of online assessments, and specifically online summative assessments, higher education institutions had to consider alternative practices (Weleschuk, Dyjur & Kelly, 2019). Proctoring tools became a key component of online summative assessment practices. According to Coghlan, Miller and Paterson (2021), the term proctoring refers to any online invigilator applications that can authenticate the identity of a student and the originality of the assessment submitted by each individual student. Online proctoring solutions claim to efficiently monitor students' assessment practices in an online environment by combining artificial intelligence (AI) algorithms and human examiners (Coghlan et al., 2021). Where human invigilators were used prior to COVID-19 (especially during summative assessment practices) to monitor the authenticity of assessment activity executions, such invigilators were then replaced by software in the online environment (Thombare, Sapate, Rane & Hutke, 2022).

In as much as proctoring tools offer opportunities to monitor the quality of assessment practices, these tools are not foolproof and do not prevent the execution of unethical behaviour during summative assessments (Lee & Fanguy, 2022). Utilising technology to monitor student behaviour and ensure the integrity of the assessment process in higher education has become the norm and has expanded during and post the COVID-19 period, according to Stephens (2021). The view that advocates the expansion of technology to ensure the integrity of online assessments supports the argument by Woldeab and Brothen (2019), that teaching, learning and assessment in the 21st century is impossible without the use of varied technology tools. Whilst striving towards ensuring the integrity and trustworthiness of assessment practices, proctoring tools offer solutions to detect anomalies by monitoring students whilst engaged in summative assessment activities. Linked to the use of proctoring tools, the aim of this research is to explore opportunities and obstacles in the use of such tools at a comprehensive open distance e-learning (CODeL) university in South Africa.

CONTEXTUALISING THE RESEARCH

Hussein et al. (2020) state that interest in online assessment practices and the use of proctoring tools have increased since the COVID-19 pandemic. Despite this interest, Kharbat & Daabes (2021) state that more research is required to explore the impact of proctoring tools on online examination experiences. Aligned to this need for additional research, the emphasis of this study is to identify the challenges and opportunities related to the use of online proctoring to support the integrity of summative assessment practices at a CODeL institution. A CODeL higher education institution refers to a multi-dimensional institution aimed at promoting the objectives of online learning, to overcome distance, temporal and spatial barriers (Manyike, 2017). Openness is important to provide students from diverse educational and socio-economic backgrounds with the opportunity to engage in further and lifelong learning. E-learning brings a new dimension to the concept of open learning to overcome traditional barriers to education. The possibilities of unlimited access to information and global communication offered via e-learning, provide students with opportunities to control and direct their own learning. To promote e-learning, the CODeL framework is founded on the premise that student learning can be optimally supported by modern electronic technologies, where multiple teaching, learning and assessment strategies and a range of technologies are used, combined with the deployment of physical and virtual resources, to encourage active engagement with students (Heeralal, 2015). The selection of technologies is determined by cognitive, affective and systemic structures (Fynn & Janse van Vuuren, 2017). In terms of cognitive support, technology is utilised to optimise access to resources, such as literature and formal learner support services related to tutorial classes, engagement with academics and peers and assessment practices. Affective support refers to the improvement of the study environment to build commitment and self-esteem, whilst systemic support is concerned with the technology infrastructure to enable students to experience comprehensive learning, engagement and support.

Pertaining to cognitive support towards enhanced assessment practices via technology, the transition from venue-based to non-venue based summative assessments was exacerbated by the outbreak of the COVID-19 pandemic (Hussein et al., 2020). Higher education institutions implemented alternate assessment methods such as timed tests, take-home exams, randomised multiple-choice exams, and online portfolio examinations, by using various technology tools (Majola & Mudau, 2022). However, ensuring the integrity of such online assessments, according to Noorbehbahani, Mohammadi and Aminazadeh (2022), require that practices of cheating and unethical behaviours of students be minimised. Therefore, many higher education institutions adopted proctoring technologies (Lee & Fanguy, 2022). The use of proctoring tools became imperative, according to Swart (2015) as well as van Breda & van Wyk (2018) to minimise cheating, assessment anomalies, and unauthorised help to students during summative assessments. Hussein et al. (2020) postulate that for online proctoring to function effectively, academics must explore ways in which proctoring tools can be used efficiently This include ascertaining experiences related to the positive use of proctoring tools, as well as obstacles that may result from the use of proctoring tools. As explained by Holden et al. (2021), such understanding will improve the use of proctoring tools as part of ensuring the integrity of summative assessment practices.

BRIEF LITERATURE REVIEW

The emerging online summative assessment strategies are achievable through the availability of technological developments. These include computers, laptops, digital cameras, headphones, and smartphones, as well as AI tools such as Scikit Learn, Keras and TensorFlow. AI tools offer machine-learning opportunities and allow for the creation of neural networks and graphical visualisation that can run on computers, Android and iSO devices (UNESCO, 2022). Through a combination of technology tools, classroom instructions and assessments can be expanded to foster engagement, creativity, and knowledge exchange (Phuthela & Dwivedi, 2020). Online assessments, and in particular summative assessments can create opportunities to support problem-based learning, and to encourage students to engage actively and creatively in solving real-world problems that they may encounter in their different professions (Gilbert, 2022). Online summative assessment practices also save money in that students in an ODeL context do not need to travel to examination centres to engage in summative assessments to sit for their examinations. Money is also saved on printing and logistical costs. Academics can build databases of questions that may be posed to students on a rotational basis; thereby minimising the opportunity for students to collaborate during summative assessments (Kharbat & Daabes, 2021).

In as much as online assessments can contribute to enhanced learning, it may also impede learning. Challenges of Internet connectivity and data access, digital incompetency, readiness, and support may negatively impact on the ability of students to engage positively in summative assessment opportunities (Majola & Mudau, 2022). There is a necessity to ensure that ~~the~~ staff and students know how to and are comfortable to engage with online summative assessments (Hussein, et al., 2020). This requires extensive knowledge of the learning management system (LMS) used by a higher education institution to create an infrastructure for teaching, learning and assessment. Examples include Blackboard, Moodle and Sakai (Badaru & Adu, 2022). Though all these systems are capable of hosting online examinations (Al-Zoubi, Dmour & Aldmour, 2022), issues may be experienced with catering for different types of assessments or different grading methods (Gilbert, 2022). Though instant grading via assessments, linked to multiple-choice exams may be supported through an LMS, questions that involve interpretation and longer answers cannot be auto assessed. An academic or assessor is still required to read through, and grade answers, though AI and machine learning will improve auto-grading in the future (Lee & Fanguy, 2022).

For the present, one of the key problems experienced during assessments, and particularly summative assessments, relates to unethical student behaviour. Since the emergence of online examinations, institutions have explored possible methods to guarantee academic integrity and institutional prestige after discovering academic fraud in unproctored online assessments (Khalil, Prinsloo & Slade, 2022). Gilbert (2022) explains that no matter the online environment, there will always be opportunities for unethical behaviour such as cheating, sharing examination answers with others or obtaining support from a third party. The key to curbing such inappropriate behaviour is using online proctoring. Kharbat & Daabes (2021) expand that it is only using methods such as proctoring that the integrity of online summative assessments can be assured. The importance of utilising proctoring tools during online assessments has also been emphasised by Duncan and Joyner (2022), who articulate that e-proctoring technologies are key to monitor online summative assessments. It is only through such proctoring tools that students' identities can be validated, suspicious activities flagged, plagiarism identified and cheating discouraged.

An online or e-proctoring system is an intelligent practical approach to meeting the need for online examination, according to Jia and He (2021). Lee and Fanguy (2022) indicate that online proctoring tools emerged in 2008 and has gained favour during and past the COVID-19 pandemic. Educational institutions all over the world employ numerous online examination proctoring systems that provide diverse solutions to lowering the likelihood of cheating (Masud, Hayawi, Mathew, Michael & El Barachi, 2022). These proctoring tools may range from simplistic tools that limit the number of opportunities that may be given to a student to complete an assessment (non-AI driven), to proctoring tools that examine recordings of online summative assessments to identify suspicious behaviour (AI driven) (Lee & Fanguy, 2022). AI is useful for mobile ID biometric verification (fingerprint, face, and voice), and identifying potential infractions and probable fraud activity through screenshots, audio recordings, and video (Slusky, 2022). In terms of the use of the latter type of proctoring tools, Kharbat & Daabes (2021) explain that through webcams, screens and microphones, students' movements and their environments can be monitored during online summative assessments, to ensure the integrity of the examination process.

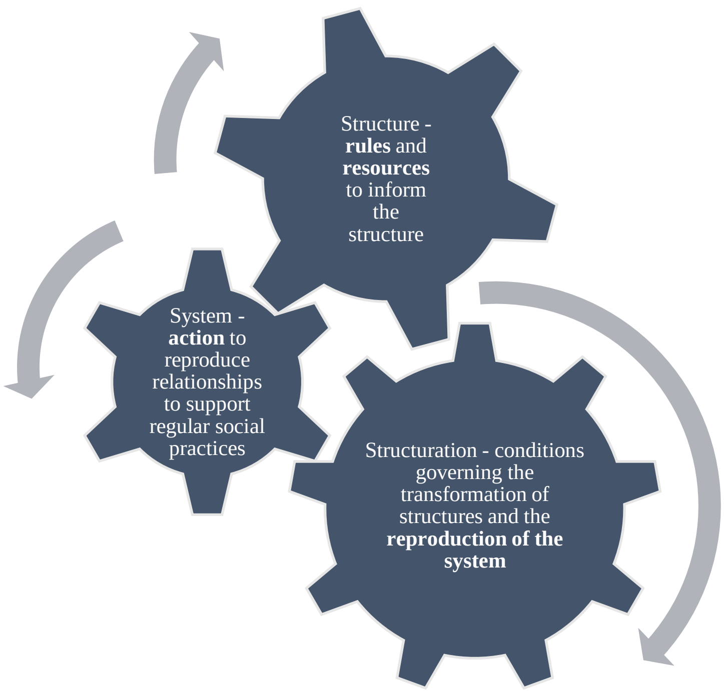
Castets-Renard and Robichaud-Durand (2022) declare that the degree to which an online proctoring tool can be used with success will depend on the extent to which technology tools are used to monitor and track student behaviour. E-proctoring tools with access to microphones, webcams and a 360° view of a student's workspace will be more effective than a tool that merely randomises questions to prevent students from sharing answers. Through the continuous development of AI-based proctoring technologies, higher education institutions will be more successful in minimising cheating or inappropriate behaviour during summative assessments (Takyar, 2022). Sridhar and Rajshekhar (2022) support this view by explaining that the increasing need for effective and efficient proctoring tools will encourage designers and developers to be more creative in providing solutions to enhance the integrity of online summative assessments. Developments in AI and machine-learning proctoring may therefore continuously enable higher education institutions to secure the integrity of their summative assessment practices through advanced proctoring technology (Coghlan, Miller & Paterson, 2021).

THEORETICAL FRAMEWORK

Theories are important 'priori' to be used as an explanatory lens to interpret patterns of events (Shanks & Bekmamedova, 2013). Furthermore, a theoretical exploration provides a context in which to explain and understand the findings of research (Ngulube, 2018). It provides direction, gives meaning to the research enterprise and assists in the identification of key findings. To execute this research, the Giddens Structuration theory was applied, to provide a framework for key components to consider in exploring opportunities and obstacles relevant to the use of proctoring tools at a CODeL university. This multidisciplinary theory is based on the premise of social action, which argues that society should be understood in terms of action and structure (Englund, Gerdin & Burns, 2011). Three key components inform the structuration theory, namely the structure, system, and structuration. The structure can be described as rules and resources established as part of a social system. These are rules that humans draw from and reproduce as they take some form of action, based on what is socially accepted (Jones & Karsten, 2003). The second component relates to system, which describes repeated relationships between rules and society that are organised as common social norms. The third component refers to structuration or the production and reproduction of social systems brought about by the interaction of rules and resources (Orlikowski & Robey, 1991).

The inter-relationship between these three components enables structures of social systems such as rules to inform social practices (systems). But social practices are also informed by resources that influence structure and actions. Neither structure, nor action can exist independently and together form the structuration, where structures create social action and social action supports structures (Corgi, 2022). Figure 1 provides an overview of the inter-relationship of the components structure and action (system) to create structuration:

Figure 1:
Structuration theory: Some basic concepts



Giddens (1984: 66)

Contextualised for this research, the description of the Giddens Structuration theory by Thompson (2017) provides the context for the examination of a proctoring tool for an information literacy module at an online distance e-learning institution. Within the context of summative assessment practices, academic integrity is key to ensure trustworthiness and validity of assessment outcomes. To ensure the upkeep of the integrity of social structures such as higher education institutions, agents in the form of academics and students are responsible for perceptions about academic integrity. If students do not follow rules to adhere to ethical practices, the integrity of the higher education system will fail. To encourage students to apply these rules, academics at higher education institutions have become reliant on proctoring technology, to ensure that regular social practices associated with the completion of summative assessments are adhered to. Assuring the maintenance of the structure of higher education thus require rules and resources, such as proctoring tools, to be implemented to ensure the action of maintaining the integrity of online summative assessment practices. This interpretation is supported by the views of Tanner and Piper (2010) who explain that rules related to academic honesty and respect and the preservation of these through measures such as proctoring tools, are important to maintain structuration.

RESEARCH METHODOLOGY

The research methodology provides the 'blueprint' for how research is to be executed (Grant & Osanloo, 2014:12). This study opted to follow a collaborative autoethnographic design to explore the views of academics on the use of proctoring tools to enhance the integrity of summative assessments in higher education. Collaborative autoethnography expands on a well-known idea of qualitative research, while suggesting a whole new method for gathering social data (Stigter, 2016). The application of collaborative autoethnography was conducted within the context of an interpretivist paradigm, where the theoretical framework provided the ontological context (depth and detail) within which the authors used self-reflection and dialogue to explore experiences pertaining to proctoring, related to a wider cultural and social understanding of the use of technology. Roy and Uekusa (2020:384) refer to collaborative autoethnography as a 'commentary', which involves exploring experiences of scholars. Miyahara and Fukao (2022:2) expand on this description by indicating that collaborative autoethnography refers to the collaboration between two or more researchers to gain meaning and understanding related to a phenomenon. Collaborative autoethnography provides opportunities for collaboration where researchers are giving the opportunity to become self-focused in certain context and dialogue through critical reflection, interaction, and exploration. While teaching information literacy skills, we started wondering: how has the use of proctoring tools influenced engagement in summative online assessments? From an epistemological point of view, the construction of knowledge was a democratic process (McMillan & Schumacher, 2010:370), which involved searching for our personal experiences in the use of proctoring tools and comparing these to literature that presented larger cultural and social meanings, to enhance understanding. The emerging qualitative research technique of collaborative autoethnography enabled the authors to explore the topic of proctoring in a highly personalised manner (Wall, 2006). During collaborative autoethnography, the authors retrospectively and selectively shared their experiences. The aim is to look at experiences analytically and present them in such a way that they may relate to others.

Collaborative autoethnography primarily has its roots in two long-standing approaches to inquiry and meaning making: autobiography and ethnography (Ellis, Adams & Bochner, 2011). Edwards (2021) posits a deep emergence in self-experience and reflection. Roy and Uekusa (2020:386) argue that collaborative autoethnography as a qualitative method can be used to gain insight and a rigorous understanding of experiences. It is not the retelling of a personal narrative but a careful organisation of systematically collected and analysed data (Miyahara & Fukao, 2022:2). This rigorous understanding of issues requires the application of ethical conduct to ensure an objective reflection of the events under consideration. Such objectivity requires that personal views be compared with existing sources and with the views of others involved in the research. As both researchers share experiences and expertise in the discipline of Information Science, it was a natural choice to share first-hand experiences of using proctoring tools as they relate to summative assessments pertaining to this discipline. In short, Information

Science is the science and practice that deals with the collection, storage, retrieval and use of information. It includes areas of recordable information and knowledge, and the use of technologies to facilitate the management and use of information (Association of Information Science and Technology, 2023). The researchers opted for the collaborative autoethnography approach because they have been employed at a CODeL university for more than ten years and have first-hand experience of the use of proctoring tools in online summative assessments. This study, which involves two collaborators who trust each other, began and aimed to make the shift from the individual collective agency to a more comprehensive understanding of the use of proctoring in continuous assessment. Lapadat (2017) postulates that when personal experiences are acknowledged, respected, and seen as embedded within workplaces and social structures, people are more likely to work together to change the workplace and societal practices, therefore working towards structuration to improve structures and systems.

COLLABORATIVE AUTOETHNOGRAPHIC ENGAGEMENT: FINDINGS

Linked to the structuration theory, the researchers for this study engaged in discussions to explore three components relevant to structure and systems namely, rules, resources (structure) and action (system). Related to these components, the autoethnographic discussion revolved around questions about what rules or guidelines were in place to guide academics and students through the process of utilising proctoring tools, where and how proctoring tools would be used, and how academics could ensure the optimum use of proctoring tools, to ensure that the integrity of summative assessments could be attained. In addition, the discussion focused on training interventions that were required to support approved practices of no cheating during summative assessments, and the identification of obstacles and further opportunities for the use of proctoring technology.

Rules and guidelines pertaining to proctoring technology use

Hussein et al. (2020) explain that the use of proctoring tools requires two key components, namely a web-camera linked to the student's device to record the physical learning space and a lockdown space, to ensure that students do not obtain input or guidance from other parties. Similarly, Fiano, Medina and Wahlen (2022) argue that parties involved in the proctoring process should be clearly informed about the requirements needed to use proctoring technology and their roles and responsibilities. The importance of understanding the way proctoring should be applied and the rules to follow, was a key point of discussion among the researchers. Since the implementation of proctoring was a new addition to online summative assessment during COVID-19, academics had to engage in extensive training to familiarise themselves with how proctoring tools operate, the requirements to ensure that students were not disadvantaged unnecessarily, and how information could be transferred to students to ensure that all parties involved in the summative assessment process were well-informed. In collaboration with academics within the Department of Information Science and support departments related to teaching, learning, quality assurance and module development within the CODeL university, a guideline was compiled to provide understanding of the scope and context of proctoring technology. The document provided detail on requirements to be put in place to ensure the effective use of proctoring technology, and how students should be supported to prepare for the use of proctoring during summative assessments. Detail about proctoring tools were communicated with students via the institutional website, but also through announcements sent out via the learning management system. It was explained that invigilator tools require a laptop, desktop or smartphone with a functional camera, as well as reliable Internet connectivity, and a head and shoulder profile picture of the student to be uploaded onto the learning management system prior to the summative assessment (UNISA, 2022). Although the information that was presented to staff and students was deemed sufficient at the time, it became evident during the online summative assessments that more information was needed to prepare staff to use proctoring technology and for students to fully understand how to engage with the technology, without it negatively impacting on the assessment process (Gous, 2019).

Support departments within the CODeL environment embarked on an extensive testing and training project to support academics in understanding proctoring tools and their uses. Fiano et al. (2022) explain that testing is imperative to provide detailed information to academics on the functions of proctoring technology and the impact (positive and negative) of the use of these technologies. Internal training on proctoring technologies was provided on a weekly basis, coupled with Moodle (LMS) Café sessions, where staff could discuss the use of the tools with ICT experts. More updated 'how to' manuals were also made available with screenshots, to assist lecturers in understanding the back-end use of the proctoring technology, and how to link the technology to summative assessment sites. Within the Department of Information Science, Moodle-champions were appointed and extensively trained, so that they could provide additional support and assistance to other academics, who had to learn how to utilise proctoring technology most effectively. These champions were able to provide hands-on guidelines and assistance to support other academics in uploading and activating the proctoring technology to their online summative assessment sites, to ensure the integrity of the examination processes.

In addition, an extensive campaign was launched by the CODeL university to inform students of the rules and guidelines pertaining to the use of proctoring technology. This campaign involved the distribution of e-mails with clear guidelines as to the use of proctoring tools and the requirements to engage effectively in the use of proctoring technology, reasons for the use of proctoring technology, and mitigating rules if proctoring negatively affected a student during the summative assessment process. Tutorial letters with guidelines on the use of proctoring technology were used to portray 'a more complete view of the phenomenon' (Muncey, 2005). However, the use of Teams sessions to prepare students for the use of online proctoring and the offering of mock examinations to practice the use of proctoring technology, lay the groundwork to prepare students for the use of such technology. During Teams sessions, online demonstrations were given on how to activate web cameras and to ensure that the environment around the student was sufficiently quiet to yield a positive proctoring report. Hussein et al. (2021) explain that such demonstrations provide opportunities for students in a non-threatening environment to practice the use of proctoring technology. Although students tend not to participate in Teams sessions, the authors found that students were particularly interested in sessions on proctoring, especially when they had not had the opportunity to use it before. Coupled with a live engagement during mock examinations, students could learn quickly how to follow guidelines provided via e-mail and announcements on activating the web camera, uploading photos where required, unblocking the web camera if blocked by mistake, and refreshing the camera if Internet connectivity had been lost (UNISA, 2022).

Resources relevant to proctoring technology use

Fiano et al. (2021), as well as Hussein et al. (2022) explain that a technology infrastructure must be in place for proctoring technology to be effectively used. Depending on the scope of proctoring required and the technology infrastructure available within a higher education institution, various types of online proctoring may be considered. Proctortrack (2021) refers to these as Proctorlock, where proctoring data captured include video, audio and desktop screenshots, ProctorAuto, which provides an automatic identity verification, data recording and data analysis, and ProctorTrack QA, where the emphasis is on manual quality assurance reviewed by trained proctors. In addition, ProctorLive AI as a type of proctoring technology, provides real-time hybrid solutions via remote invigilation and human proctors with AI proctoring capabilities, to identify suspicious behaviour and activities. Due to the large number of students involved in summative assessments at the CODeL university, the introduction of a new LMS, namely Moodle, and the inexperience of staff in the use of proctoring technology, the Proctorlock type was mostly used during summative assessments to ensure the integrity of the examination process. This means that screenshots are taken at various intervals via web cameras, videos, and audio, as well as a desktop, to ensure that the correct student is writing the assessment, without assistance from other parties, and who can complete the assessment within the set timeframe given for the examination.

Though the required resource and infrastructure to execute the Proctorlock type seem simple enough, the researchers found that it was not the case. Due to the digital divide in South Africa and other areas in Africa where students embark on summative assessments, many students do not have access to the necessary hardware or network infrastructure to execute the guidelines for using the proctoring technology. The lack of infrastructure, data, and resources to engage in online proctoring technology is emphasised by Woldegiorgis (2022), who explains that students from disadvantaged backgrounds are influenced the most by the move to online summative assessments and the use of proctoring technology. In South Africa there is still inadequate digital infrastructure, lack of funds for digital investment, and a lack of digital literacy (Gqoboka, Anakpo & Mishi, 2022). In the appropriation of proctoring tools, the type of device the student owns and how it works with proctoring software became important considerations, because some students don't have a laptop to study with, and instead engage in online assessments via their cell phones. (Ndovela & Marimuthu, 2022). Even for those who own devices, the issue of access is costly. Rahman (2022) discloses that the biggest obstacles to successfully using online proctoring systems include increased prices of data, a shortage of appropriate devices, limited bandwidth in remote locations, and students' technological limitations. This poses a challenge to academics to customise online examination, so that it can be conducted on a mobile application. Encouraging the use of mobile applications may be necessary because, as affirmed by Bejrajh and Themane (2022), the majority of South African students own smartphones that can be used more effectively to engage in academic activities. Though the CODeL university does supply students with data to engage in educational activities, the researchers acknowledge that the amount of data is not sufficient to properly train and encourage students to utilise proctoring technology during online assessments. In fact, a trend developed where students would log on to a summative assessment site, activate the proctoring tool and leave before completing the assessment, possibly due to data shortage. This phenomenon, however, requires more investigation to confirm the assumption.

Actions towards proctoring use

A third component of the structuration theory, focused on the systems component relates to action. The agency of action is critical to reproduce and encourage transformation within a specific context. Individuals involved in creating the action are required to bring about change, whilst also reproducing rules and resources contextualised during the structure part of the structuration theory (Thompson, 2017). To achieve action, Pham (2019) proposes that interaction and routinisation, based on knowledge of the structure, be considered. Agents should rationalise rules and resources, and in doing so, coordinate ongoing projects, whilst contextualising and performing actions. While considering this component of the structuration theory, the researchers discussed the future use of proctoring technology and its expansion to enhance the integrity of summative assessment processes. The researchers agreed that for proctoring to be efficient, attention should be given to the technology infrastructure of the examination system, both within the institution and for students. Our experience was that during examinations, the system would often fail due to large volumes of activity; implying that neither academics, nor students could engage with summative assessment activities.

The issue pertaining to the stability of the examination system emanated in the resetting of examination question papers and offering of additional examination opportunities, so that students could complete summative assessments within a trustworthy and reliable environment. This not only increased the workload of academics, but also brought clashes between summative assessments scheduled for students studying towards a degree in information science. Similar experiences were shared during joint operations meetings with academics from other departments. For students, the instability of the examination system brought about anxiety, uncertainty and loss of valuable data that was needed to complete the summative assessment. It also created opportunities for students to share questions that they had already answered with other students, leading to large scale engagement with assessment questions and answers in the hope of receiving similar question papers. None of this was conducive towards supporting the integrity of the online summative assessment process. What did however arise, was insight into the urgent need for academics to train students on issues of avoiding plagiarism, institutional policy requirements towards the integrity of the examination process and digital literacy. Towards maintaining and improving structuration, such training is deemed imperative to bring about transformation towards the improved and sustained use of proctoring during summative assessment activities.

DISCUSSION OF FINDINGS: OPPORTUNITIES AND OBSTACLES

The proctoring systems and their tools have brought many opportunities for academics and students at the CODeL university. Prior to COVID-19, the institution had been theorising about and strategising for online assessments. However, the outbreak of the pandemic forced the CODeL university to offer fully online summative assessments, linked to proctoring tools, to ensure the integrity of the process. The use of proctoring technology reduced the costs of human invigilators and enhanced the opportunity for students to engage in summative assessment activities in an environment most comfortable to them. The hiring and maintenance of examination venues have also been minimised because students are no longer conducting examinations in these venues. Students have also reduced their transport costs since they are no longer expected to travel to physical venues to take examinations. The online summative assessment process enhanced the security of examinations, as academics do not have to worry about the unauthorised sharing of examination scripts, or the late arrival of summative assessment scripts at the examination venues. There were, however, costs involved in the purchasing and use of proctoring tools. These costs were excessive during the initial purchase and implementation, but over time has become minimal, as the purchase was once-off and the tools are available on the examination system for future use. What is important is that the costs are determined by the type of proctoring tools used. Whilst some proctoring tools can be purchased as a software programme for continuous use, others require the purchase of licensing. Licensed proctoring can become excessively expensive, as licenses must be purchased for each student during each examination period. This is, however, not the type of proctoring tool used by students engaged in the information literacy module. The proctoring tool used was purchased by the university with little additional cost to execute during each examination.

A variety of online summative assessment methods were also introduced, to provide variety and assess the understanding, application, analysis and evaluation skills of students. Students' engagement with various assessment methods could all be monitored through online proctoring technology, to ensure the integrity of the process. Examples of assessment methods include multiple choice true/false assessments, completion of short answer assessments and fill in the missing word assessments. To offer these online summative assessment methods, sustainable ICT infrastructure is imperative, to ensure the effective execution of the summative assessment process and the use of proctoring technology. In our experience, the instability of the system was the main reason why students and staff struggled with proctoring technology and its application. Another issue that impacts negatively on the use of proctoring technology relates to the scattered geographic areas from where students engage in assessment activities. Many students enrolled at the CODeL university are from rural areas, where access to Wi-Fi, Internet, and ownership of devices are still challenges. Internet connection, including issues of data bundles for many students, has not been fully addressed. Some had to share a computer and connection with friends, neighbours and the rest of the family, all of which impact negatively on the proctoring report produced for those students. Limited technology knowledge was also perceived as an obstacle. As academics, we would teach our students how to access the proctoring tools and webcam devices. Some of them often asked, '*what is the webcam*'. This is an indication that some students lack the necessary skills to engage online, whether for studies or assessment in a CoDEL institution.

Lee & Fanguy (2022) state that the adoption of online proctoring technologies has produced negative impacts on students' and lecturers' subjectivities, pedagogical relationships and educational outcomes. This was evident in the increased aggression and frustration levels expressed by students during Teams sessions or e-mail correspondence, as experienced by the authors. In communication to the authors, students blamed academics for poor performances or the inability to activate proctoring tools (Hybertext, 2023). The use of different assessment methods frustrated students, as they often felt ill-prepared to engage in answering questions related to analysis and evaluation. In such instances, students reverted to copy and paste activities from existing sources to produce possible answers; thereby extending, rather than minimising instances of cheating. Students also found it difficult to transition from venue-based to non-venue based summative assessments, and to take responsibility for their own actions to ensure the integrity of the examination process (Dyomfana, 2021).

CONCLUSION

The research has shown that rules, resources and actions are needed for the effective and continuous use of proctoring technology to support the integrity of summative assessment processes. Related to the structuration theory, more time and engagement is needed for students and academics to find a space where social systems pertaining to the use of proctoring technology can become a familiar norm and be expanded to include more advanced technology, to ensure the integrity of the summative assessment process. Reciprocity between staff, students and other members of the CODeL community is important, as it will impact the nature of interaction in the use of proctoring technology. This reciprocity will also influence the rules and resource requirements necessary, to ensure a continuous flow of activities related to proctoring use that are reflexively monitored.

Lee & Fanguy (2022:12) declare that 'it is difficult to know whether the benefits of these online proctoring technologies outweigh their risks. The most reasonable conclusion is that the ethical justification of these technologies requires us to ensure that a balance is struck between the concerns and the possible benefits.' Related to this view, enhanced focus on reshaping the thoughts of students on cheating and academic integrity is needed to discourage unethical behaviour. Though proctoring technology can support the integrity of the assessment process, it is more important that students act ethically, based on their own convictions to support validity, trustworthiness and accountability as part of the summative assessment processes. Within the context of information science, this requires extensive training on the ethics of information, knowledge sharing and digital literacy. As a way forward, it is proposed that the Department focuses on the development of open educational resources on these topics that can be shared, not just with students from the Department, but with all students studying at the CODeL institution.

REFERENCES

Al-Zoubi, A., Dmour, M. & Aldmour, R. (2022) Blockchain as a Learning Management System for Laboratories 4.0. *International Journal of Online & Biomedical Engineering* 18(12) pp.16-34.

Association of Information Science and Technology. (2023) *What is information science?* https://www.asist.org/about/what-is-information-science/ (Accessed 30 January 2023).

Badaru, K.A. & Adu, E.O. (2022) Platformisation of Education: An Analysis of South African Universities' Learning Management Systems. *Research in Social Sciences and Technology* 7(2) pp.66-86.

Bejrajh, V. & Themane, M. (2022) Using Smartphones in Teaching English to Secondary School Students in South Africa. *Interdisciplinary Journal of Education Research* 4 pp.76-90.

Castets-Renard, C. & Robichaud-Durand, S. (2022) Online Test Proctoring Software and Social Control: Is the Legal Framework for Personal Information and AI Protective Enough in Canada? *Blockchain and*

Artificial Intelligence Solution to Enhance the Privacy in Digital Identity and Internet of Things. Forthcoming: Taylor & Francis/CRC Press.

Clay, J. (2020) *Digital assessment in higher education*, https://ijtl.iie.ac.za/newpage5c162231 (Accessed 30 January 2023).

Coghlan, S., Miller, T. & Paterson, J. (2021) Good proctor or "big brother"? Ethics of online exam supervision technologies. *Philosophy & Technology* 34 pp.1581-1606.

Corgi. (2022) *Anthony Giddens and the theory of structuration*. https://studycorgi.com/anthony-giddens-and-the-theory-of-structuration/ (Accessed 30 January 2023).

Duncan, A. & Joyner, D. (2022) On the necessity (or lack thereof) of digital proctoring: Drawbacks, perceptions, and alternatives. *Journal of Computer Assisted Learning* 38(5) pp.1482-1496.

Dyomfana, B. (2021) *Unisa's rule for online exams.* https://www.careersportal.co.za/education/universities/unisas-rules-for-online-exams (Accessed 30 January 2023).

Edwards, J. (2021). Ethical autoethnography: Is it Possible? *International Journal of Qualitative Methods* 20(3), doi:10.1177/1609406921995306

Ellis C., Adams T. E. & Bochner A. P. (2011) Autoethnography: An overview. *Forum Qualitative Sozialforschung/Forum: Qualitative Social Research*, 12(1) p.10, http://nbn-resolving.de/urn:nbn:de:0114-fqs1101108 (Accessed 30 January 2023).

Englund, H., Gerdin, J. & Burns, J. (2011) 25 years of Giddens in accounting research: achievements, limitations and the future. *Accounting, Organisations and Society* 36 pp.494-513.

Fiano, K.S., Medina, M.S. & Whalen, K. (2021) *The need for new guidelines and training for remote / online testing and proctoring*. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8500292/ (Accessed 30 January 2023).

Fynn, A. & Janse van Vuuren, H. (2017) Investigating the role of non-academic support systems of students completing a Master's Degree in Open, Distance and e-Learning. *Perspectives in Education*, 35(1) pp.186-199.

Giddens, A. (1984) *The construction of society. Outline of the theory of structuration*. Berkeley: University of California Press

Gilbert, C. (2022) *Advantages and disadvantages of online examination system.* https://cirrusassessment.com/advantages-and-disadvantages-of-online-examination-system/ (Accessed 30 January 2023).

Gous, N. (2019) *Students who leaded exams papers faced up to five years' suspension: Unisa.* https://www.timeslive.co.za/news/south-africa/2019-05-27-students-who-leaked-exam-papers-face-up-to-five-years-suspension-unisa/ (Accessed 30 January 2023).

Gqoboka, H., Anakpo, G. & Mishi, S. (2022) Challenges Facing ICT Use during COVID-19 Pandemic: The Case of Small, Medium and Micro Enterprises in South Africa. *American Journal of Industrial and Business Management* 12(9) pp.1395-1401.

Grant, C. & Osanloo, A. (2014) Understanding, selecting and integrating a theoretical framework in dissertation research: Creating the blueprint for your house. *Administrative Issues Journal: Connecting Education, Practice and Research.* Volume 4(2) pp.12-26 https://files.eric.ed.gov/fulltext/EJ1058505.pdf (Accessed 30 January 2023).

Heeralal, P.J.H. (2015) Improving postgraduate supervision in an open and distance learning environment: A case study at the College of Education, University of South Africa. *South African Journal of Higher Education* 29(3) pp.87-100.

Holden, O.L., Norris, M.E. & Kuhlmeier, V.A. (2021) *Academic integrity in online assessment: A research review*. https://www.frontiersin.org/articles/10.3389/feduc.2021.639814/full (Accessed 30 January 2023).

Hussein, M.J., Yusuf, J., Deb, A.S., Fong, L. & Naidu, S. (2020) An evaluation of online proctoring tools. *Open Praxis* 12(4) pp.509-525.

Hypertext. (2023) *Unisa's online exams to become a permanent fixture.* https://htxt.co.za/2020/09/23/unisas-online-exams-to-become-a-permanent-fixture/ (Accessed 30 January 2023).

Jia, J. & He, Y. (2021) The design, implementation and pilot application of an intelligent online proctoring system for online exams. *Interactive Technology and Smart Education* 19(1) pp.112-120.

Jones, M.R. & Karsten, H. (2003) Giddens's structuration theory and information systems research. *MIS Quarterly*, 32 pp.127-157.

Khalil, M., Prinsloo, P. & Slade, S. (2022) In the nexus of integrity and surveillance: Proctoring (re) considered. *Journal of Computer Assisted Learning* 38(6) pp.1–14. https://doi.org/10.1111/jcal.12713 (Accessed 30 January 2023).

Kharbat, F.F. & Daabes, A.S. (2021) *E-proctored exams during the COVID-19 pandemic: A close understanding*. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7884061/ (Accessed 30 January 2023).

Lapadat, J.C. (2017) Ethics in autoethnography and collaborative autoethnography. *Qualitative inquiry 23*(8) pp.589-603.

Lee, K. & Fanguy, M. (2022) *Online exam proctoring technologies: educational innovation or deterioration?* https://bera-journals.onlinelibrary.wiley.com/doi/full/10.1111/bjet.13182 (Accessed 30 January 2023).

Majola, M.X. & Mudau, P.K. (2022) Lecturers' Experiences of Administering Online Examinations at a South African Open Distance E-Learning University during the COVID-19 Pandemic. *International Journal of Educational Methodology* 8(2) pp.275-283.

Manyike, T.V. (2017) Postgraduate supervision at an open distance e-learning institution in South Africa. *South African Journal of Education* 37(2) pp.1-11.

Masud, M.M., Hayawi, K., Mathew, S.S., Michael, T.& El Barachi, M. (2022) Smart Online Exam Proctoring Assist for Cheating Detection. *International Conference on Advanced Data Mining and Applications* pp.118-132.

McMillan, J.H. & Schumacher, S. (2010) *Research in Education. Evidence-based inquiry*. (7th ed.) Boston: Pearson.

Miyahara, M. & Fukao, A. 2022. Exploring the use of collaborative autoethnography as a tool for facilitating the development of researcher reflexivity. *System* 105(102751) pp. 1-9.

Muncey T. (2005) Doing autoethnography. International *Journal of Qualitative Methods* 4(3) p.5, http://www.ualberta.ca/~iiqm/backissues/4_1/pdf/muncey.pdf (Accessed 30 January 2023).

Ndovela, S. & Marimuthu, M. (2022) aMangosuthu University of Technology, Umlazi, South Africa, University of KwaZulu-Natal, Durban, South Africa. *Academic Voices* p.443.

Ngulube, P. (2018) *Handbook of research on heritage management and preservation*. Pennsylvania: IGI Global.

Noorbehbahani, F., Mohammadi, A. & Aminazadeh, M. (2022) A systematic review of research on cheating in online exams from 2010 to 2021. https://link.springer.com/article/10.1007/s10639-022-10927-7 (Accessed 30 January 2023).

Orlikowski, W.J. & Robey, D. (1991) Information technology and the structuring of organisations. *Information Systems Research* 2(2) pp.143-169.

Peñalvo, F.J., Gorell, A., Garcia, V.A. & Prado, M.G. (2020) *Recommendations for mandatory online assessment in higher education during the COVID-19 pandemic.* https://link.springer.com/chapter/10.1007/978-981-15-7869-4_6 (Accessed 30 January 2023).

Pham, H.T. (2019) *The application of structuration theory in studying collaboration between librarians and academic staff in universities in Australia and Vietnam*. http://informationr.net/ir/24-3/paper829.html (Accessed 30 January 2023).

Phuthela, N. & Dwivedi, S. (2020) A qualitative study of students' perspective on e- learning adoption in India. *Journal of Applied Research in Higher Education* 12(4) pp.545-559. https://doi.org/10.1108/JARHE-02-2019-0041 (Accessed 30 January 2023).

Proctortrack. (2021) *Online proctoring technology: Key to secure online exams*, https://www.proctortack.com/blog/article/online-proctoring-technology-key-to-secure-online-exams (Accessed 30 January 2023).

Rahman, A. (2022) Mapping the Efficacy of Artificial Intelligence-based Online Proctored Examination (OPE) in Higher Education during COVID-19: Evidence from Assam, India. *International Journal of Learning, Teaching and Educational Research* 21(9) pp.76-94.

Roy, R. & Uekusa, S. (2020) Collaborative autoethnography: 'self-reflection" as a timely alternative research approach during the global pandemic. *Qualitative Research Journal* 20(4) pp.382-392, doi:10.1108/QRJ-06-2020-0054

Shanks, G. & Bekmamedova, N. (2018) *Case study research in information systems.* https://www.researchgate.net/publication/323515278_Case_study_research_in_information_systems (Accessed 30 January 2023).

Slusky, L. (2020) Cybersecurity of online proctoring systems. *Journal of International Technology and Information Management 29*(1) pp.56-83.

Sridhar, A. & Rajshekhar, J.S. (2022) AI-Integrated Proctoring System for Online Exams. *Journal of Artificial Intelligence* 4(2) pp.139-148.

Stephens, N.M. (2021) *How to catch student exam cheating with remote proctoring*. https://assess.com/remote-proctoringsecurity/ (Accessed 30 January 2023).

Stigter, S. (2016) Autoethnography as a new approach in conservation. *Studies in Conservation* 61(2) pp.227-232.

Swart, O. (2015) Alternative Assessments: The journey from venue-based examinations to take-home and online timed assessments. Proceedings of the 14th World Conference on Mobile and Contextual Learning, mLearn, Venice, Italy, October 17-24. Springer International Publishing, pp. 378-390.

Takyar, A. (2022) *Remote proctoring using AI – Enabling seamless management of online examinations*. https://www.leewayhertz.com/remote-proctoring-using-ai/ (Accessed 30 January 2023).

Tanner, L. & Piper, C. (2010). *Succumbing to temptation – to cheat or not to cheat? Faculty and student perceptions of academic integrity in distance education courses*. https://www.learntechlib.org/p/35760/ (Accessed 30 January 2023).

Thompson, K. (2017) *Giddens' structuration theory – a summary.* https://revisesociology.com/2017/03/02/giddens-structuration-theory-a-summary/ (Accessed 30 January 2023).

UNESCO. (2022) *Artificial intelligence in education*. https://www.unesco.org/en/digital-education/artificial-intelligence (Accessed 30 January 2023).

University of South Africa (2023) *Know your proctoring tools for the examination*. https://www.unisa.ac.za/sites/myunisa/default/Announcements/Know-your-proctoring-tools-for-the-examination (Accessed 30 January 2023).

University of South Africa. (2022). *Activating your camera for Moodle proctoring tool for MCQ examinations*. https://www.studocu.com/en-za/document/university-of-south-africa/introduction-to-african-philosophy/activating-your-camera-for-moodle-proctoring-tool-for-mcq-examinations-edited-23may2022/29161775 (Accessed 30 January 2023).

van Breda, M. & van Wyk, M. (2018) Electronic-Portfolio Approach to Enhance Self-Directed Learning. *Transnational Perspectives on Innovation in Teaching and Learning Technologies* pp.45-66. Brill.

Wall, S. (2006) An Autoethnography on Learning About Autoethnography. *International Journal of Qualitative Methods* 5(2) pp.146-160. https://doi.org/10.1177/160940690600500205 (Accessed 30 January 2023).

Weleschik, A., Dyjur, P. & Kelly, P. (2019) *Online assessment in higher education*. https://taylorinstitute.ucalgary.ca/sites/default/files/TI%20Guides/Online%20Assessment%20Guide-2019-10-24.pdf (Accessed 30 January 2023).

Woldeab, D. & Brothen, T. (2019) Twenty-first century assessment: online proctoring, text anxiety and student performance. *International Journal of E-Learning and Distance Education* 34(1) pp.2-10. https://files.eric.ed.gov/fulltext/EJ1227595.pdf (Accessed 30 January 2023).

Woldegiorgis, E.T. (2022) Mitigating the digital divide in, the South African higher education system in the face of the COVID-10 pandemic. *Perspectives in Education* 40(3) pp.197-211. doi: http://dx.doi.org/10.18820/2519593X/pie.v40.i3.13 (Accessed 30 January 2023).

Students' perceptions of Computerised Adaptive Testing in higher education[8]

Priya Ramgovind, The Independent Institute of Education, South Africa
Shamola Pramjeeth, The IIE's Varsity College, South Africa

ABSTRACT

The COVID-19 pandemic has forced higher education institutions (HEIs) to re-look at their assessment strategy as learning, development, and engagement move more fluidly into the online arena. The purpose of this research was to investigate students' academic and personal perceptions of computer adaptive testing (CAT) in higher education to understand students' confidence in adopting CAT. Using a quantitative descriptive research design, an online questionnaire was administered to students at private and public HEIs in South Africa, with 600 respondents. The study found that the students were comfortable engaging in online learning and expressed positive perceptions of adopting CAT, with most respondents recommending it for implementation. Students believe that CAT allowed for more productive interaction with material which meets their needs and learning preferences without feeling overburdened. The findings of the study provide HEIs with valuable information on key managerial implications to ensure the successful adoption and implementation of CAT.

Keywords: adaptive testing, assessment methodology, computerised, student perceptions, post- COVID-19 pandemic

INTRODUCTION

Student learning styles, the speed at which they can assimilate information, and their abilities to comprehend what is being taught are different and unique to everyone (Peng, Ma & Spector, 2019). Presently, HEIs have fit-for-purpose standardised assessment strategies that are most suited to every module's needs, and overall qualification. Most of these assessment strategies were designed for a face-to-face medium/mode of delivery, namely paper-based standardised testing and catering to the masses of students. With the COVID-19 pandemic, lecturers and students had to adapt their varying learning styles and abilities forcefully and quickly to an additional complexity that is online learning. This area was unfamiliar to many. Two years into the COVID-19 pandemic, with many institutions using online learning as a key delivery medium, learners and lecturers are beginning to embrace online learning more, due to its adaptability and flexibility (Mpungose, 2020; Zalat, Hamed & Bolbol, 2021). With the COVID-19 pandemic having challenged and changed conventional teaching and learning assessment practices, learners are beginning to reflect on their learning preferences and styles.

[8] Date of Submission: 24 October 2023

Date of Review Outcome: 2 March 2023

Date of Acceptance: 15 September 2023

The forced use of online learning caused by the pandemic has shown HEIs and lecturers that personalised learning is possible. Online platforms have enabled the easy collection and real-time analysis of a wide range of information on numerous aspects of learners' behaviour and competency, with the ability to provide more detailed and meaningful feedback quicker to learners through their smartphone/tablet devices. A generic one-size-fits-all assessment strategy that dominated testing before the pandemic warrants a call for a renaissance in assessment practices (New Meridian, 2022). Therefore, as online learning and the way students want to learn grows, the way they want to be taught and assessed must evolve. Learning should be an all-inclusive approach that is highly individualised, relative, and continuous (Elmore, 2019) between the learner and the educator, a partnership. In this role, the lecturer is more of a facilitator and activator; therefore, assessments should support such a learning form rather than measure, evaluate, and give a score (Elmore, 2019). Assessments should provide helpful information to guide, provide feedback, and promote the dynamic nature of learning. Assessments should provide more guided information about the development of learners' capabilities and understanding of content, and not about merit, pass or fail. Vander Ark (2014:1) writes that students' learning should be such that they are 'able to progress at different rates and with time and support varied to meet individual needs; increased access to care and education to better align with the realities of modern living and working; greater use of the home, the community, and other settings as contexts for 24/7 learning experience'. The forced move to online learning has resulted in students and lecturers capitalising on additional teaching and learning methods that were previously not considered given established assessment methods, which were effective in their own right. However, given the now endless assessment possibilities and the willingness of students to engage more online with their learning, an assessment method that aligns with this new digital student is computerised adaptive testing (CAT). Lee (2021) highlights that COVID-19 has been a catalyst to student-centric learning, where learning is more aligned and tailored to the student's needs and interests to ensure the 'full awareness of the learner' is attained (Kaminskiene & De Urraza, 2020:3).

The purpose of this research was to understand student perceptions and applications of CAT in South African HEIs. The key research objectives that guided this study were the following:

- To determine the level of students' knowledge and understanding of CAT.
- To determine students' personal and academic perceptions of CAT.
- To determine students' comfortability of adopting CAT as an assessment tool in their respective modules being studied.

A student-centric CAT approach to assessment is not standard practice for assessing students in HEI in South Africa, despite HEIs adopting online assessment methods (Queiros & de Villiers, 2016; Minty, 2018; Fynn & Mashile, 2022). With students engaging more in online learning and their comfortability with it increasing, the findings of this study provide HEIs with valuable information on students' comfortability with adopting such a testing methodology and whether CAT should be implemented in their HEI. With HEIs having this understanding, it will make the change in assessment strategy much easier to implement, as students' willingness to adopt and accept such a strategy is high. Currently, there is a lack of research on CAT adoption before implementation, student perceptions of CAT in the higher education space and especially in South Africa. Although CAT is not a new assessment tool, it has been implemented in first-world countries (Surpass, 2019; New Meridian, 2022), however, to a lesser extent in Africa. Furthermore, the contemporary literature lacks an understanding of student perception and of CAT prior to its implementation, especially in the South African HE environment.

LITERATURE REVIEW

Numerous countries around the world are at the tail end of responding to the COVID-19 pandemic (Charumilind, Craven, Lamb, Sabow, Singhal & Wilson, 2022). However, the effects and implications of this pandemic are still being felt and will continue to do so in the future. The teaching and learning practices that have emerged as a contingency, necessity, or reflex, have seen an increased reliance on e-Learning for those institutions with the existing infrastructure and Emergency Remote Teaching (ERT) for a more temporary solution (van Wyk, Mooney, Duma & Faloye, 2020; Zalat, Hamed & Bolbol, 2021). Therefore, the construction of a learning environment that aligns with the changing education landscape is fundamental to the transformation of teaching and learning practices (Li & Lalani, 2020). Looking ahead, HEIs will use the lessons learned from the pandemic and the continuing increase in the adoption of students and lecturers and the comfortability of online learning, to actively seek to create an adaptive e-Learning method that will leverage the electronic learning environment that is best suited to the needs of individual students (Ramadan & Aleksandrovna, 2018) and embrace the smart learning environment (Peng et al., 2019). Smart learning amalgamates smart device technologies with intelligent technologies to create a learning environment that is tailored to the needs and learning of different students, resulting in an improved and effective learning experience (Peng et al., 2019).

What are Adaptive Learning Systems?

Adaptive learning systems are digitally designed to factor in the level of ability, skill attainment, and needs of students in a manner that considers automated procedures and instructor interventions (Troussas, Krouska, & Virvou, 2017). The purpose of these systems is to use student proficiency to determine the exact knowledge of the student before they are moved sequentially along the learning path so that the learning outcomes are comprehensively achieved (Chrysafiadi, Troussas & Virvou, 2018).

CAT systems are based on testing, by which automated systems are used to self-assess and diagnose a student. The premise of CAT is to ensure that the questions posed to a student are not too difficult or too easy (Rezaie & Golshan, 2015). The use of CAT is to measure the efficiency or the accuracy of a test score with respect to the duration of the test. This implies that when using an adaptive test, a shorter duration can save time, rather than a test of equal precision, or it can improve a student's score on a test of equal duration or length (Thompson, 2019).

Computerised Adaptive Testing

Adaptive tests are created automatically by computer systems or applications, known as Computer Adaptive Tests (Vie, Popineau, Tort, Marteau & Denos, 2017). There are several types of CAT, but they all have two common steps. In the first step, the most appropriate item/s are determined and then administered based on students' current level of understanding. The second step is to use the response/s to the item/s posed and refine it until the performance estimate, or a student receives a perfect score. This two-step process continues until the student has answered a predetermined number of questions, or until a precision score has been obtained (Gibbons, Bower, Lovell, Valderas, & Skevington, 2016). To construct an algorithm that selects the most suited activity/item or exercise from a pool of tests to meet the specific needs of students requires the identification and evaluation of criteria pertaining to a student's needs and abilities.

Procedures for implementing CAT have been proposed; however, most have been proliferated, given that each institution and its requirements are different and cannot use a standardised approach (Moosbrugger & Kelava, 2012). Therefore, institutions seeking to implement CAT must understand the unique characteristics of the CAT programme. According to Ramadan and Aleksandrovna (2018), for a CAT to be truly adaptive, there are standard components that must be included. This includes the item pool, the decision rule for selecting the first time, methods for selecting additional items or a set of items, the selection of items is to maximise efficiency, and that test items must reflect a balance in content and finally the termination of criteria.

Advantages of Computerised Adaptive Testing

Thompson (2011), Rezaie and Golshan (2015), and Surpass (2019) describe the advantages of CAT as having shorter tests, in which testing time can be reduced by up to 50% or more. Equiprecision ensures that precision measurement is applied to all examinees, which results in the examination experience being more appropriate for each examinee (Zandvliet & Farragher, 1997; Baik, 2022), thus, bolstering their motivation. This is seen when low-achieving examinees feel better and high-achieving examinees feel challenged post-CAT. Furthermore, it decreases the levels of stress, anxiety, boredom, and fatigue that an examinee may experience (Ramadan & Aleksandrovna, 2018). Due to the flexibility in the algorithm of CAT, there is greater security when assessments are administered and can be adapted to various requirements. Furthermore, examinees can re-test themselves once a score has been received and they have had a chance to work on areas they are not yet competent in. The use of online assessments allows for a richer user interface to be provided to the examinee through the integrated use of graphics and allows for the dynamic presentation of assessment content (Han, 2018). A key advantage that is seen favourably by assessors is the immediate computation of scores, which allows both the examinee and the assessor to receive a quick 'snapshot' of the examinee's performance (Stone & Davey, 2011).

Disadvantages of Computerised Adaptive Testing

The benefits of CAT cannot be viewed in isolation; there are challenges associated with it, and therefore it is prudent that institutions fully understand these challenges to ensure that contingencies are made to address them or mitigate them completely. One of the most fundamental challenges of CAT is the computer literacy of students (Alderson, 2000). Students who do not have sufficient exposure to- and involvement with technology in an educational setting will struggle to adopt CAT. Furthermore, Thompson (2011) states that once a CAT has been administered, it is almost impossible for examinees to return to questions already answered. In addition, items can run the risk of being overexposed, since the best question is designed to be selected. Therefore, a control algorithm is required (Rezaie & Golshan, 2015). The test is designed to reflect the skill and ability of an examinee; however, if an examinee is experiencing extreme anxiety, this could be reflected in their attempts at the questions and given that the system will not allow for the examinee to go back to reattempt a question, examinees can be left with a poor score, not due to inability but rather testing anxiety. For the implementation of CAT to be successful, a large sample size and the necessary expertise are needed to ensure the validity and reliability of this assessment method. Therefore, an institution wanting to engage in CAT must ensure that its computer lab infrastructure will support the required number of students at a time (Oladela, Ayanwale & Owolabi, 2020).

Perceptions and Implementation of CAT

The current reliance on computers to facilitate teaching and learning has led to increased interest in facilitating assessment through online mediums. While the concept of CAT has been founded in the psychology discipline, contemporary studies conducted by Harrison, Geerards, Ottenhof, Klassen, Riff, Swan, Pusic, and Sidey-Gibbons (2019), Xu, Jin, Huang, Zhou, Li, and Zhang (2020), and Stochl, Ford, Perez, and Jones (2021) highlight the implementation of CAT. As its understanding and applicability to other disciplines grew, CAT has been found to be equally applicable and is evidenced in higher education. Studies conducted by Oppl, Reisinger, Eckmaier and Helm (2017), Eggan (2018), Diahyleva, Gritsuk, Kononova, and Yurzhenko (2020) Oladele and Ndlovu (2021), and Oladele (2021) evidenced the implantation of CAT in various higher education circumstances. Existing studies relating to student perceptions of CAT were studies undertaken by Lilley, Barker, and Britton (2005), and Lilley and Barker (2007); however, these studies were aimed at understanding student perceptions of CAT during implementation and not pre-implementation. Currently, there is no existing literature that examines the perceptions of students of CAT as a precursor to implementation. Currently, there are countless studies that are testing the efficacy of CAT in the respective disciplines. However, the literature gap appears due to there not being an understanding of student perceptions of CAT prior to the acceptance and implementation thereof in the contemporary higher education environment, especially against the backdrop of post-pandemic higher education in South Africa. Therefore, the purpose of this research is to address this literature gap, especially in the South African, context given its multicultural and multilingual students with varying socioeconomic conditions.

RESEARCH METHODOLOGY

The research paradigm that guided this study was positivism (Creswell & Creswell, 2018). The study was descriptive in nature, as the researchers aimed to describe students' perceptions and comfortability of adopting CAT considering there is currently little to no previous research to serve as a reference point on CAT as an assessment approach in the South African Higher Education (HE) landscape (Rahi, 2017; Saunders, Lewis, & Thornhill, 2019). Using a quantitative methodological approach, the study sought to understand HE students' views of adopting CAT as opposed to their standardised number of assessments and their perceptions of such a testing methodology. The questionnaire design was informed by literature on CAT. The closed-ended questionnaire assessed students' level of comfortability in online learning, their understanding and knowledge of CAT, their personal and academic perceptions of CAT, and whether they believed CAT should be implemented at their HEI. Data were collected using the Microsoft Forms online survey platform from June 2022 – July 2022. The target population for the study was students (undergraduate and postgraduate) at both private and public HEIs in South Africa. Using a nonprobability sampling methodology, namely purposive sampling, the survey link was distributed to the students, the targeted population, via email. The survey was open for responses for a period of two weeks. Institution names were not included in the survey to ensure the anonymity of the respondents. An online questionnaire was chosen as the most suitable instrument in terms of the geographical reach of public and private HEIs in the major provinces of South Africa. Using Sekaran and Bougie's (2016) sampling size table, for a target population greater than 100,000 at a 95% confidence interval, the appropriate sample size is 384. The researchers were targeting 400 responses with a 50% completion rate. A total of 600 students completed the questionnaire. Of the 600 responses, 589 were from private HEIs and 11 from public HEIs. Therefore, it should be noted that generalisation of the findings to the public HEIs must be taken with caution. The data collected from Microsoft Forms was exported to an Excel spreadsheet, cleaned, and coded. Using statistical package software, SPSS version 28, descriptive and inferential statistical analyses were performed on the data. Descriptive analyses namely mean, median, mode, and standard deviations, were performed on the data to summarise the study sample characteristics and establish the means, quantiles, and measures of dispersion in the data. Cross-tabulations with chi-square and Cramer's V testing were also performed. Exploratory factor analysis (EFA) was performed to explore its structure. To assess whether there is a significant correlation between the factors, Pearson Correlation coefficients were obtained. Before performing the exploratory factor analysis (EFA), the suitability of the data should be assessed. This is done using the Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO-MSA), and Bartlett's Test of Sphericity. The KMO-MSA value had to be greater than 0.5 and the Bartlett test of Sphericity, statistically significant. As seen in Table 1 below, both conditions were satisfied and therefore the data was considered suitable to perform the EFA analysis. To assess internal consistency of each factor, a Cronbach's Alpha reliability test was performed, with a 0.786 score being returned, and thus deemed adequate to perform EFA.

Table 1:
KMO and Bartlett's Test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.848
Bartlett's Test of Sphericity	Approx. Chi-Square	1182.329
	df	36
	Sig.	0.000

The ethical approval for the study was obtained from the Independent Institute of Education according to its ethics review and approval procedures (R. 00036).

RESULTS AND DISCUSSION

The following discussion presents the findings of the study, which are further corroborated and/or refuted by the findings of the relevant literature.

Table 2:
Demographics of participants

	Frequency	Percent
Gender		
Male	171	29
Female	423	71
Age		
18-20 Years	228	38
21-25 Years	290	48
26-30 Years	29	5
31-35 Years	16	3
> 35 Years	37	6
Mode		
Full-time	510	85
Part-time	66	11
Distance	24	4
Student type		
Undergaduate	522	87
Postgraduate	72	12
FET/TVET	6	1
Year of study		
First year	270	45
Second Year	156	26
Third year	120	20
Fourth year	54	9
Qualification		
Degree	408	68
Diploma	72	12
Higher Certificate	72	12

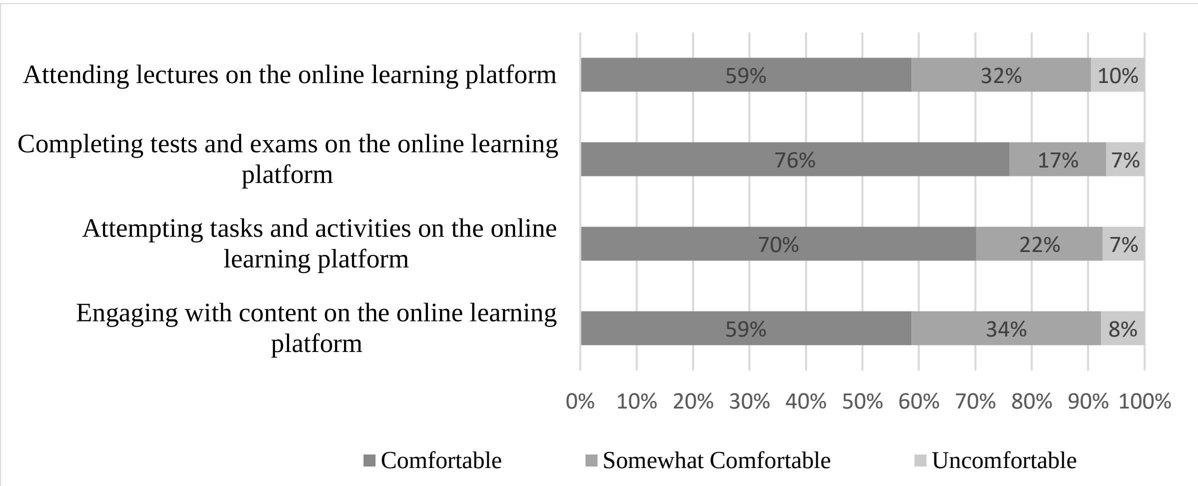
Postgraduate	48	8

A total of 600 students completed the online questionnaire. Most of the students were within the 18-25 age range (86%), with more females (71%) responding to the survey. In terms of mode of study, 85% were full-time students with 87% being undergraduate students. In terms of the study year, 45% were first-year students, 26% were second-year, 20% were third year, and 9% were in their fourth year of study. In terms of qualification, majority (68%) were studying toward a degree.

Engagement of students in online learning and testing

Students were asked if they have engaged in online learning and testing. Ninety-three percent indicated yes, while 7% indicated no. Of the 93% who engaged in online learning and testing, the majority expressed that they were comfortable with it, with 76% feeling most comfortable completing tests and exams on the online platform, followed by trying tasks and activities (70%), as depicted in Figure 1. Regarding engaging with the content and attending lectures online, only 59% felt comfortable, indicating that students may prefer face-to-face interaction with the lecturer and learning materials. Alkamel, Chouthaiwale, Yassin, AlAjmi, and Albaadany (2021) found similar findings of positive attitudes toward online testing in their study of postgraduate and undergraduate students, with, Yıldırım, Erdoğan, and ve Çiğdem (2017) noting that students were comfortable with the system and lecturer feedback, but found that the allotted time to complete the assessment was insufficient, there were challenges of access to a device, and accessing the online testing system were experienced.

Figure 1:
Level of comfortability with the following areas in online learning



A cross-tabulation and the associated chi-square and Cramer's V test were performed to determine whether there was a statistically significant association between participants' views on:

I. Adopting adaptive testing and their comfortability with the online learning platform: lecturers. It was found that the association was statistically significant with a small effect size ($X2(4)=65.953, p<0.01, Cramer's\ V=0.25$).
II. Adopting adaptive testing and their comfortability with the online learning platform: content engagement. The association was found to be statistically significant with a small effect size ($X2(4)=27.834, p<0.01, Cramer's\ V=0.156$).
III. adopting adaptive testing and its comfortability with the online learning platform: tasks and activities. It was found that the association was statistically significant with a small effect size ($X2(4)=26.933, p<0.01, Cramer's\ V=0.154$).

IV. Adopting adaptive testing and their comfortability with the online learning platform: tests and exams. It was found that the association was statistically significant with a small effect size ($X2(4)=26.933, p<0.01, Cramer's\ V=0.154$).

Table 3:
Cramer's V value:

Cramer's V value	Effect Size Interpretation
0.10 < V < 0.3	Small Effect
0.3 < V < 0.5	Medium/Moderate Effect
V > 0.5	Large Effect

Knowledge and Understanding of CAT

The purpose of CAT and how it is implemented, were explained to the students. They were then provided with statements describing CAT's key characteristics and features to determine their level of knowledge and understanding of what CAT is before establishing their perceptions of it being used as an assessment tool. In terms of understanding that CAT uses automated testing, only 49% of the students were aware of it, and 58% knew that AT allows instantaneous feedback. Most of the students (70%) were aware that CAT allowed lecturers to understand areas students were having difficulty with, thus personalising their teaching, and students' learning. Overall, the students showed a good understanding and knowledge of what CAT is, according to Table 4. The EFA analysis was performed on Knowledge and Understanding of CAT, and one factor was extracted using the Principal Axis Factoring (PAF) with a minimum factor loading of 0.4, with a KMO of 0.848.

Table 4:
Knowledge and Understanding of CAT

	Agree	Neutral	Disagree
CAT utilises automated testing processes.	49%	46%	5%
CAT is computer-aided tests that are designed to adjust the level of difficulty based on students' responses.	64%	30%	6%
CAT enables distinct learning at an individualised level of teaching and learning.	68%	28%	4%
CAT is a learning system that adjusts to the level of a student's abilities, needs, or skills that is aligned with the student's performance.	67%	27%	5%
CAT allows students to master concepts/skills before they can move on to a new concept/skill or learning area.	65%	29%	6%
CAT sequentially moves students through learning outcomes based on their level of understanding and competency.	63%	32%	5%
CAT allows for instantaneous feedback.	58%	34%	8%
CAT allows the student to view the scores immediately after completion of the test.	60%	30%	10%
CAT allows lecturers to understand areas students are having difficulty with, thus personalising their teaching and students' learning.	70%	23%	7%

The students were asked to express how comfortable they felt they would be in adopting CAT as an assessment tool in their current studies after learning about the key characteristics and features of CAT depicted in Table 4. Most felt comfortable (63%), 33% somewhat comfortable, and 4.4% were uncomfortable with adopting CAT in their current studies. Based on Table 5, the second and third years seem more comfortable with adopting CAT (64% of the grand total, respectively) compared to the first and fourth-year students (61%), although the percentage difference is minimal. One would assume that first years are new to the tertiary space and still getting familiar with the online systems and testing methodology, while the fourth years engage in more critical and application/practical-based questioning and thus would feel more comfortable with paper-based testing as they may be unfamiliar with this level of testing in an online format.

Table 5:
Cross-tabulated year of study with the comfortability of adopting CAT

Year of Study	Comfortable	Somewhat uncomfortable	Uncomfortable	Grand Total
First year	27.6%	16.1%	1.0%	44.7%
Second year	16.9%	7.9%	1.5%	26.3%
Third year	12.9%	5.9%	1.3%	20.1%
Fourth year	5.4%	3.0%	0.5%	8.9%
Grand Total	62.8%	32.8%	4.4%	100.0%

Personal Perceptions of CAT

Students were asked to rate the following statements to assess their personal perceptions of CAT, and to determine if specific requirements and considerations that are needed for them to engage with CAT. The EFA analysis was performed, and one factor was extracted using PAF with a minimum factor loading of 0.4. A single factor was extracted for the Personal Perceptions of Adaptive Testing, with a KMO of 0.708. Four statements that did not load with the factor, was item PPAT2: 'If you are digitally confident, would you engage in AT?', PPAT3 'If you are not digitally confident, would you upskill yourself to engage with AT?', PPAT7 'Should additional support and training regarding AT be provided by a trained facilitator?', and PPAT8 'Should additional support and training regarding AT be provided online?'.

Table 6:
Personal Perceptions of CAT and specific requirements and considerations

		Agree	Neutral	Disagree
Are you digitally confident that you can engage CAT as an assessment method?	PPAT1	67%	29%	4%
If you are digitally confident, would you engage in CAT?	PPAT2	70%	27%	3%
If you are not digitally confident, would you upskill yourself to engage with CAT?	PPAT3	65%	27%	8%
Do you have the technological infrastructure to facilitate your use of CAT in your home?	PPAT4	74%	20%	6%

Would you have to make use of campus technology infrastructure to facilitate your use of CAT?	PPAT5	38%	26%	36%
Would you require additional support and training when engaging in CAT?	PPAT6	43%	36%	21%
Should additional support and training regarding CAT be provided online?	PPAT7	73%	22%	5%
Would you be able to source your own data/Wi-Fi when required to engage with CAT?	PPAT8	70%	21%	10%
Would you need to use the institutions' data/Wi-Fi when required to engage with CAT?	PPAT9	38%	32%	30%
CAT would hinder my academic performance given that I am not digitally comfortable with navigating online platforms.	PPAT10	18%	32%	50%

Students indicated a willingness to upskill themselves for CATs where they did not have the necessary skills (65%) and welcomed additional support and training online on CAT (73%). They showed significant digital confidence in engaging with CAT (67%). This is validated by Song, Singleton, Hill, and Koh (2004), who indicate that learner motivation, time management, level of comfort with online technology, and course design impact a student's online learning experience. Although there is an initial degree of hesitancy because CAT is not currently integrated into the academic assessment structure of students, it can be overcome through the training and support of students. Student perceptions in an introductory managerial accounting class found that students had both negative and positive perceptions of computerised testing due to the influence and management of student perceptions by individual instructors (Apostolou, Blue & Daigle, 2009). Thus, highlighting the critical role of lecturers, facilitators, or teachers in the implementation of CAT's. Martin (2018) found that CAT exhibits positive effectiveness for older students.

Most students have infrastructure at home to assist with online learning and would therefore be able to successfully engage in CAT for modules in which they are registered. Hogan (2014) investigated the efficiency and precision of CAT and computer classification and found that test coordinates favoured the use of CAT over pencil and paper assessments when assessed. Having the appropriate technological infrastructure and access to data/Wi-Fi plays a critical role in CAT's success. Students indicated that they have the required technological infrastructure (74%) and access to data/ Wi-Fi (70%) to facilitate their use of CAT at home. Fifty percent disagreed that CAT would hinder their academic performance, since they are not digitally comfortable navigating online platforms.

Academic Perceptions of CAT

Students were asked to evaluate the following statements to assess their academic perceptions of CAT and to determine if specific requirements and considerations are needed for them to engage with CAT.

Table 7:
Academic Perceptions

		Agree	Neutral	Disagree
CAT can be used in a course/module you are enrolled in.	APAT1	68%	27%	6%
CAT can be a more effective way to assess a course/module you are enrolled in.	APAT2	64%	30%	7%
CAT can be used together with existing assessment methods.	APAT3	75%	22%	3%
CAT is suited for your registered mode of offering (i.e., full-time or distance).	APAT4	62%	31%	7%
CAT can be used at my NQF level	APAT5	62%	31%	7%
CAT can be used for numeracy modules, for example, accounting.	APAT6	50%	35%	15%
CAT can be used for theoretical heavy modules, for example, business management, law, etc.	APAT7	57%	32%	11%
CAT will allow me to work constructively through content without being overwhelmed.	APAT8	62%	32%	6%
CAT allows me to work through content at my own pace.	APAT9	73%	25%	3%
CAT can allow me to develop skills and competencies at the best-suited pace for me.	APAT10	74%	23%	4%
Understanding my score will allow me to understand my areas of weakness and where improvement is required.	APAT11	85%	13%	2%
CAT should be only engaged during allotted times (i.e., the same duration of a test or exam).	APAT12	37%	36%	28%
CAT should be always open to engagement (i.e., 24/7).	APAT13	73%	22%	5%
CAT can assist with removing the ability to plagiarise an assessment.	APAT14	63%	30%	7%

Students demonstrate a significant degree of comfort with CAT in their individual modules (68%), NQF level (62%) and mode of delivery (62%). There is a sense of individual learning that is paced for the student based on their needs (74%) that creates a sense of individuality for the student, despite being in a collective classroom. In addition to this, the students felt that CAT would allow them to work constructively through the content without being overwhelmed (62%). Martin (2018) validates the notion that CAT better matches items with examinees, which leads to minimal errors and enhanced precision.

Students are of the opinion that having more time to complete adaptive tests (73%) will ensure that they are able to work at their own pace and understanding their scores will allow them to determine their own areas of weaknesses and address them going forward (85%), which is crucial for students to help build and reinforce students taking accountability and responsibility for their learning. Given that a single summative end-of-year examination, with one or two formative assessment points, can only give you a limited view of a student's progress (New Meridian, 2022), lecturers can construct a richer profile of students' development by combining multiple measures throughout the year, which guides instruction and offers comparable data that reveals where additional resources are needed (New Meridan, 2022).

Lilley and Barker (2007) found that students performed better in summative- than in formative assessments, and that they an overall good attitude toward automated feedback that is individualised based on student performance. To further understand student success, Almahasees, Mohsen and Amin (2021) found that online learning allows for flexibility in learning due to students having access to learning material at all times of the day.

Students agreed (63%) that the use of CAT will help reduce the ability to plagiarise assessments. However, Meuschke, Gondek, Seebacher, Breitinger, Keim and Gipp (2018), Denney, Dixon, Gupa and Hulphers (2021), and Sorea, Rosculet and Bolborici (2021) indicate that for plagiarism to be effectively detected and managed in online learning, students must be trained in referencing and paraphrasing. The authors postulate further that educators must be more involved in educating students on referencing and identifying plagiarism issues; at the same time, the institution must have clear plagiarism policies, software, and ethical education practices.

The EFA analysis was performed, and two factors were extracted using PAF with a minimum factor loading of 0.4. Two factors were extracted for Academic Perceptions of Adaptive Testing as per Table 6, with a KMO of 0.803. The first factor consisted of three items, APAT8' AT will allow me to work constructively through content without being overwhelmed', APAT9' AT allows for me to work through content at our own pace', and APAT10' AT can allow for me to develop skills and competencies at a pace best suited to them'.

The second factor consisted of three items, APAT1' AT can be used in the course/module I am learning', APAT2' AT can be a more effective way to assess a course/module I am enrolled in', and APAT4' AT is suited for all modes of offering (i.e., full-time or distance)'.

Table 8:
Personal Perceptions Factors

Pattern Matrix[a]		
	Factor 1	Factor 2
APAT1		0.802
APAT2		0.777
APAT4		0.432
APAT8	0.601	
APAT9	0.739	
APAT10	0.843	

To determine whether there are significant relationships between the factors in the study, Pearson's correlation coefficients were obtained for the factors (using the factor scores), Table 8. The relationships between many of the factors were shown to be statistically significant. All statistically significant relationships were positive. Once the statistical significance and direction of the relationships were assessed, the strength of the relationship can be assessed using the correlation coefficient value. The following guideline can be used to interpret the correlation coefficients.

Table 9:
Correlation Interpretation

$\lvert r \rvert < 0.3$	Small
$0.3 < \lvert r \rvert < 0.5$	Medium/Moderate
$\lvert r \rvert > 0.5$	Large

Table 10:
Pearson's Correlation Coefficients

		ATF1	APATF1	APATF2	PPATF1
Student	ATF1	1	.364**	.442**	-.205**
	APATF1		1	.513**	-.175**
	APATF2			1	-.128**
	PPATF1				1

Table 10 notes the relationship between the factors on Knowledge and Understanding of Adaptive Testing (ATF1) and Academic Perception of Adaptive Testing factor 1 (APATF1) was found to be statistically significant and moderately positive ($r = 0.364$, $p < 0.01$). Furthermore, a statistically significant and moderately positive relationship ($r = 0.442$, $p < 0.01$) was found between AFTF1 and APATF2. This indicates that the higher the level of Adaptive Testing (the better the understanding), the higher the Academic Perception of Adaptive Testing factors 1 and 2.

Recommend the use of CAT for their HEI

Out of 599 responses, on a scale of 1 to 10, with 1 being 'Extremely Not Confident' and 10 being 'Extremely Confident', do you believe that CAT is the future of assessing students' knowledge and competence in a module, an average score of 7.4 was received, implying that students are confident in CAT as an assessment tool, as HEIs evolve in the post-COVID and technology-driven world.

Students were asked, 'Do you believe your higher education institution should implement CAT as an assessment tool?' Eighty-seven percent believe their HEI should implement CAT, while 13% indicated no.

IMPLICATIONS AND WAY FORWARD

Based on the findings in this study, some of the managerial implications are that HEIs must identify an information technology system that is suitable for use. The installation of the necessary computer lab infrastructure to support the system that caters to many students at a time is required; however, this has a major cost implication for an HEI. Lecturers/academics designing the items for the CAT must be trained on how to develop items that serve the intended purpose and allow for the scaffolding of learning. Lecturers/academics must display digital competence to ensure the successful use of CAT and not perpetuate digital hesitancy among students who may be uncertain. Ongoing training and discussions on what are working and what is not, must be part of the culture to ensure an excellent student-centric personalised learning experience. Students must be trained and taught the use and functionality of CAT. They must also allow students to work on a demo system that does not provide automatic grading before their performance is measured to familiarise them with the technology and assessment tool. To address the challenge of overexposing items in the CATs, HEIs need to factor in a control algorithm (Rezaie & Golshan, 2015) therefore, requiring specialist skills. Due to this system being new, it is advised that a full-time information technology support specialist is available to assist students and lecturers, and to address system issues that are raised. Furthermore, the issue of plagiarism has been compounded in the years since the presence of COVID-19. Students have found increasingly innovative ways to plagiarise when learning online. Therefore, despite there being no comprehensive literature that attributes the implementation of CAT to a decrease in student plagiarism, there are plagiarism policies, procedures, and workshops that must be provided to students to ensure that the culture and ethics pertaining to plagiarism are ingrained into students, and thus ensuring that the use of CAT is effective.

For CAT to be successful in its implementation and facilitation, there must be understanding and buy-in from key stakeholders. Thus, lecturers and/or academics who design CAT items must be fully aware of the needs and requirements of their course before engaging in the development of adaptive tests. Additionally, students as users must be trained, confident, and competent in digital literacy to ensure that it does not hinder their learning experience. One of the challenges of CATs is that once they have been administered, it is almost impossible for examinees to return to questions already answered; thus, it is crucial for HEIs to look at possible ways of addressing this to better assist and support students. This will also help reduce stress and anxiety in students. It is vital that the implementation of CAT is done thoughtfully and skilfully to ensure that the benefits associated with this teaching and learning practice are fully harnessed, irrespective of the socio-economic background of students in South Africa.

CONCLUSION

The study has established that most of the students have a positive attitude towards adopting CAT as a new testing methodology and believe that their HEI should implement CAT. They are comfortable completing tests, examinations, and activities online and have the digital competence to engage with CAT. Students who feel they have the required level of digital confidence are willing to improve their skills and are open to support and training if offered online. Should their HEI implement CAT, they have to have the adequate technology, infrastructure, and access to data/Wi-Fi to engage with the CAT at home, thus, not to be reliant on the institution's devices and data/Wi-Fi. They believe that CAT will allow them to engage with content more constructively at the time and pace that best suits their needs and learning styles without becoming overwhelmed, allowing them to develop the competencies and skills required. Based on the score obtained after completing the CAT, students believe that it will enable them to understand their areas of weakness and where improvement is needed, thus improving their competence and fostering the ownership of learning.

The contribution of this study is that there is a dearth of contemporary literature and studies related to understanding student perceptions of CAT prior to its adoption in higher education. This information is critical in post-pandemic South African HEIs, especially given the historic economic, social, and environmental challenges faced by higher education students. By understanding student perceptions towards CAT, any challenges or hesitancies around online learning can be mitigated to ensure buy-in and success, as opposed to exacerbating challenges associated with online learning, which was evidenced during the COVID-19 pandemic. Therefore, post-pandemic, understanding of students, academics, and personal perceptions towards the adoption of CAT will provide HEIs with pertinent contemporary knowledge to aid in decision making going forward. The information gleaned from this study is one that has not yet been constructed against the backdrop of a post-pandemic South African higher education setting.

A key limitation of this study was that of time and access to the student population in public HEIs in SA. Thus, areas of future research for implementing CAT would be to expand the sample population to include a more significant representation of public university students.

REFERENCES

Alderson, J.C. (2000) Technology in testing: The present and the future. *System* 28(4) pp.593-603.

Alkamel, M.A.A., Chouthaiwale, S.S., Yassin, A.A.A., AlAjmi, Q. & Albaadany, H.Y. (2021) Online testing in higher education institutions during the outbreak of COVID-19: Challenges and opportunities. *Studies in Systems, Decision and Control* 348 pp.349-363.

Almahasees, Z., Mohsen, K. & Amin, M.O. (2021) Faculty's and students' perceptions of online learning during COVID-19. *Frontiers in Education* 6:638470, doi:10.3389/feduc.2021.638470

Apostolou, B., Blue, M.A. & Daigle, R.J. (2009) Student perceptions about computerised testing in introductory managerial accounting. *Journal of Accounting Education* 27(2) pp.59-70.

Baik, S. (2022) *Computer adaptive testing – Pros & cons,* https://codesignal.com/blog/tech-recruiting/pros-cons-computer-adaptive-testing/ (Accessed 26 September 2022).

Barros, J.P. (2019) Students' perceptions of paper-based vs. computer-based testing in an introductory programming course. *Proceedings of the 10th International Conference on Computer Supported Education, (CSEDU 2018)* pp.303-308.

Charumilind, S., Craven, M., Lamb, J., Sabow, A., Singhal S. & Wilson, M. (2022) When will the COVID-19 pandemic end? https://www.mckinsey.com/industries/healthcare/our-insights/when-will-the-covid-19-pandemic-end (Accessed 13 March 2023).

Choi, I., Kim, K.S. & Boo, J. (2003) Comparability of a paper-based language test and a computer-based language test. *Language Testing* 20 pp.295-320.

Chrysafiadi, K., Troussas. & Virvou, M. (2018) A framework for creating automated online adaptive tests using multiple-criteria decision analysis. *2018 IEEE International Conference on Systems, Man and Cybernetics* (SMC) pp.226-231.

Creswell, J.W. & Creswell, J.D. (2018) *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). USA: Sage Publications.

Denney, V., Dixon, Z., Gupta, A. & Hulphers, E. (2021) Exploring the perceived spectrum of plagiarism: A case study of online learning. *Journal of Academic Ethics* 19(2) pp.187-210.

Diahyleva, O.S., Gritsuk, I.V., Kononova, O.Y. &Yurzhenko, A.Y. (2020). Computerised adaptive testing in education electronic environment of maritime higher education institutions. *CTE Workshop Proceedings* 8 pp.411-422.

Dillon, A. (1992). Reading from paper versus screens: A critical review of the empirical literature. *Ergonomics* 35 pp.1297-1326.

Eggan, T.J.H.M. (2018). Multi-segment Computerized Adaptive Testing for educational testing purposes. *Fronters in Education* 3 p.111.

Elmore, R.F. (2019) The Future of Learning and the Future of Assessment. *ECNU Review of Education* 2(3) pp.328-341.

Fynn, A. & Mashile, E.O. (2022) Continuous online assessment at a South African open distance and e-learning institution, *Frontiers in Education* 7:791271, doi:10.3389/feduc.2022.791271

Gibbons C, Bower P, Lovell K, Valderas J. & Skevington S. (2016) Electronic quality of life assessment using computer-adaptive testing. *Journal of Medical Internet Research* 18(9) p.240.

Han, K.C.T. (2018) Conducting simulation studies for computerised adaptive testing using SimulCAT: An instructional piece. *Journal of Educational Evaluation for Health Professions* 15(20) p.20.

Harrison, C.J., Geerards, D., Ottenhof, M.J., Klassen, A.F., Riff, K.W.Y. Q., Swan, M. C., Pusic, A. L. & Sidey-Gibbons, C.J. (2019) Computerised adaptive testing accurately predicts CLEFT-Q scores by selecting fewer, more patient-focused questions. *Journal of Plastic, Reconstructive and Aesthetic Surgery* 72 pp.1819-1824.

Hogan, T. (2014) *Using a computer-adaptive test simulation to investigate test coordinators' perceptions of a high-stakes computer-based testing program*. PhD Thesis, Georgia State University, US.

Ita, M.E., Kecskemety, K.M., Ashley, K.E. & Morin, B. (2014) Comparing student performance on computer-based vs. paper-based tests in a first-year engineering course. *Proceedings of the 121st ASEE Annual Conference & Exposition* Indianapolis, Indiana, US 15-18 June, pp.1-14.

Kaminskiene, L. & DeUrraza, M.J. (2020) The flexibility of curriculum for personalised learning. *Proceedings of the 14th International Scientific Conference on* Society. Integration, Education. Rezekne, Latvia, 22-23 May, 3 pp.266-273.

Khoshsima, H., Toroujeni, S.M.H.T., Thompson. N. & Ebramhimi, M.R. (2019). Computer-based (CBT) vs. paper-based (PBT) testing: Mode effect, relationship between computer familiarity, attitudes, aversion and mode preference with CBT test scores in an Asian private EFL context. *Teaching English with Technology* 19(1) pp.86-101.

Lee, K.H. (2021) *The educational 'metaverse' is coming. The Campus Learn, Share, Connect.* https://www.timeshighereducation.com/campus/educational-metaverse-coming (Accessed 15 August 2022).

Li, C. & Lalani, F. (2020) The COVID-19 Pandemic has changed education forever. This is how. World Economic Forum. https://www.weforum.org/agenda/2020/04/coronavirus-education-global-covid19-online-digital-learning (Accessed 20 September 2022).

Lilley, M. & Barker, T. (2007) Students' perceived usefulness of formative feedback for a computer-adaptive test. *Electronic Journal of e-Learning* 5(1) pp.31-38.

Lilley, M., Barker, T. & Britton, C. (2005) Learners' perceived level of difficulty of a computer-adaptive test: A case study. *In: Costabile, Human-Computer Interaction* 3585 pp.1026-1029.

Meuschke, N., Gondek, C., Seebacher, D., Breitinger, C., Keim, D. & Gipp. B. (2018) An adaptive image-based plagiarism detection approach. *Proceedings of the 18th ACM/IEEE on Joint Conference on Digital Libraries (JCDL '18). Association for Computing Machinery, New York, NY, US*, pp.131-140.

Minty, R. (2018) To use electronic assessment or paper-based assessment? That is the question (apologies to Shakespeare), *The Independent Journal of Teaching and Learning* 13(1) pp.17-27.

Moosbrugger, H. & Kelava, A. (2012) Testtheorie und Fragebogenkonstruktion. *In Statistik für Human- und Sozialwissenschaftler*, pp.7-26.

Mpungose, C.B. (2020) Emergent transition from face-to-face to online learning in a South African university in the context of the Coronavirus pandemic. *Humanities and Social Sciences Communication* 7(13) p.113.

Nergiz, C. & Seniz, OY. (2013) How Can We Get Benefits of Computer-Based Testing in Engineering Education? *Computer Applications in Engineering Education* 21(2) pp.287-293.

New Meridian. (2022) Flexible *Assessment Systems Enable Educators to Respond to Students' Needs and Expand Educational Equity*. https://newmeridiancorp.org/ (Accessed 03 March 2022).

Noyes, J.M. & Garland, K.J. (2008) Computer- vs. paper-based tasks: Are they equivalent? *Ergonomics* 51(9) pp.1352-1375.

Oladela, J. & Ndlovu, M.C. (2021) A review of standardised assessment development procedure and algorithms for computer adaptive testing: applications and relevance for Fourth Industrial Revolution. *International Journal of Learning, Teaching and Educational Research* 20(5) pp.1-17.

Oladela, J. (2021) Computer-adaptive-testing performance for postgraduate certification in education as innovative Assessment. *International Journal of Innovation, Creativity and Change* 15(9) pp.87-101.

Oladele, J.I., Ayanwale, M.A. & Owolabi, H.O. (2020) Paradigm shifts in computer adaptive testing in Nigeria in terms of simulated evidence. *Journal of Social Sciences* 63(1-3) pp.9-20.

Oppl, S., Reisinger, F., Eckaier, A. & Helm, C. (2017) A flexible online platform for computerised adaptive testing. *International Journal of Educational Technology in Higher Education* 14(2).

Peng, H., Ma, S. & Spector, J.M. (2019) Personalised adaptive learning: An emerging pedagogical approach enabled by a smart learning environment. *Smart Learning Environments* 6(1) pp.1-14.

Queiros, D.R. & de Villiers, M.R. (2016) Online learning in a South African higher education institution: determining the right connections for the student, *International Review of Research in Open and Distributed Learning* 17(5) pp.165-185.

Rahi, S. (2017) Research design and methods: A systematic review of research paradigms, sampling issues and instruments development. *International Journal of Economics and Management Sciences* 6(2) pp.1-5.

Ramadan, A.M. &, A.E. (2018) *Computerised Adaptive Testing.* https://www.researchgate.net/publication/329935670_Computerized_Adaptive_Testing (Accessed 03 March 2022).

Rezaie, M. & Golshan, M. (2015) Computer Adaptive Test (CAT): advantages and limitations. *International Journal of Educational Investigations* 2(5) pp.128-137.

Saunders, M., Lewis, P. & Thornhill, A. (2019) *Research methods for business students* (8th ed.). Harlow: Pearson Education Limited.

Sekaran, U. & Bougie, R. (2016) *Research methods for business: A skill building approach* (7th ed.). Singapore: John Wiley and Sons.

Song, L., Singleton, E.S., Hill, J.R. & Koh, M.H. (2004) Improving online learning: Student perceptions of useful and challenging characteristics. *The Internet and Higher Education* 7(1) pp.59-70.

Sorea D., Roșculeț G. & Bolborici A.M. (2021) Readymade solutions and students' appetite for plagiarism as challenges for online learning. *Sustainability* 13(7) p.3861.

Stochl, J., Ford, T., Perez, J. & Jones, P.B. (2021). Modernising measurement in psychiatry: item banks and computerised adaptive testing. *Lancet Psychiatry* 8(5) pp.354-356.

Stone, E. & Davey, T. (2011) Computer-Adaptive Testing for students with disabilities: A review of the literature. *ETS,* Princeton, New Jersey.

Surpass. (2019) *Computer Adaptive Testing: Background, benefits and case study of a large-scale national testing programme*. https://surpass.com/news/2019/computer-adaptive-testing-background-benefits-and-case-study-of-a-large-scale-national-testing-programme/ (Accessed 27 September 2022).

Troussas, C., Krouska, A. & Virvou, M. (2017) Reinforcement theory combined with a badge system to foster student's performance in e-learning environments. *8th IEEE International Conference on Information, Intelligence, Systems & Applications (IISA),* Larnaca, Cyprus, 27-30 August, pp.1-6.

Thompson, N.A. (2011) *Advantages of Computerized Adaptive Testing (CAT).* https://assess.com/docs/Advantages-of-CAT-Testing.pdf (Accessed 27 September 2022).

Thompson, N. (2019) *Computerised Adaptive Testing: Definition, algorithm, benefits*. https://assess.com/what-is-computerized-adaptive-testing/ (Accessed 25 September 2022).

Van Wyk, B., Mooney, G., Duma, M. & Faloye, S. (2020) Emergency remote learning in the times of COVID: A higher education innovation strategy. *Proceedings of the European Conference on e-Learning, Berlin, Germany* pp.28-30.

Vander Ark, T. (2014) *The future of Assessment. Getting Smart*. https://www.gettingsmart.com/2014/12/17/future-assessment/ (Accessed 12 May 2022).

Vie, JJ, Popineau, F., Tort, F., Marteau, B. & Denos, N. (2017) A heuristic method for large-scale cognitive-diagnostic computerised adaptive testing. *Proceedings of the 4th ACM Conference on Learning at Scale, Cambridge Massachusetts, USA.* pp.323-326.

Xu, L., Jin, R., Huang, F., Zhou, Y., Li, Z. & Zhang, M. (2020) Development of computerised adaptive testing for emotion regulation. *Frontiers in Psychology* 11 pp.1-11.

Yıldırım, O. G., Erdoğan, T. & ve Çiğdem, H. (2017) The investigation of the usability of web-based assignment system. *Eğitimde Kuram ve Uygulama,* 1 pp.1-9.

Zalat, M.H., Hamed, M.S. & Bolbol, S.A. (2021) *The experiences, challenges, and acceptance of e-learning as a tool for teaching during the COVID-19 pandemic among university medical staff.* https://doi.org/10.1371/journal.pone.0248758 (Accessed 13 June 2022).

Zandvliet, D. & Farragher, P. (1997) A comparison of computer-administered and written tests. *Journal of Research on Computing in Education* 29 pp.423-438.

Socio-economic status predicts mathematics self-concept: A correlational study in OR Tambo Inland District[9]

Ntokozo Kintosh Nogobo , Walter Sisulu University, South Africa
A. Jogymol Kalariparampil, Walter Sisulu University, South Africa

ABSTRACT

The current study explored the level to which socio-economic status predicts mathematics self-concept. A correlational and regression research designs were used. The study was carried out in OR Tambo Inland District in the Eastern Cape Province. The sample size comprised of 351 Grade 9 mathematics students, of which 171 were girls and 180 were boys. For generalizability purposes and fair distribution and representation of the sample across the population, both rural and urban geographical locations were represented by three schools each. The level of socio-economic status and mathematics self-concept was measured by use of a standardized questionnaire. The data collection tool was tested valid and reliable. Statistical Package for the Social Sciences (SPSS) was used to perform regression and correlation analysis. The research findings depict that mathematics self-concept was heavily influenced by socio-economic status of a parent. Furthermore, mathematics self-concept varied according to the socio-economic status and the variation was statistically significant. Recommendations were made to all implicated stakeholders to improvise strategies of improving mathematics self-concept despite the family's economic hardships.

Key words: parent's socio-economic status, mathematics self-concept, OR Tambo Inland District

INTRODUCTION

According to Trends in International Mathematics and Science Study (TIMSS) developed countries such as France, Italy and Turkey fail to achieve above the benchmark or international average score of 500 points in Mathematics (TIMSS, 2019). Hence, it is safe to argue that poor performance in Mathematics is a global issue. This issue becomes even more severe when it comes to developing countries such as South Africa. For example, South Africa is ranked in the second last position in Mathematics achievement across the world (TIMSS, 2019). Amidst, the global issue of Mathematics poor achievements, some scholars suggest that enhancing Mathematics self-concept may yield positive Mathematics outcomes (e.g., Marsh, 2022; Sewasew et al., 2018; Chiu & Klassen, 2010). Mathematics self-concept refers to how students perceive themselves and their abilities in mathematics (Arens et al., 2022). Mathematics self-concept does not only predict mathematics achievement, but it also impacts career aspirations in mathematics-related fields (Marsh, 2022), such as Science Technology Engineering and Mathematics (STEM). It is thus significant to enhance and keep mathematics self-concept positive as one of the strongest predictors of mathematics achievement and mathematics- related courses pursuit.

[9] Date of Submission: 25 January 2023

Date of Review Outcome: 13 June 2023

Date of Acceptance: 28 August 2023

Therefore, it is necessary to explore the contributory factors towards the development of mathematics self-concept. Amongst other things, mathematics achievement is a significant predictor of mathematics self-concept (Arens et al., 2022). Students who get good marks in Mathematics tend to perceive themselves more positively about their mathematics abilities. Additionally, gender stereotypes play a significant role on the development of mathematics self-concept (Wolff, 2021). For example, regardless that girls had significant better mathematics scores than boys, girls still perceive their mathematics abilities negatively as compared to boys (e.g., Niepel, 2019; Lee & Kung, 2018). Thus, mathematics self-concept development is mediated by gender and these variations start to manifest as early as in elementary schooling (Mejía-Rodríguez et al., 2021; Erdogan & Sengul, 2014). Furthermore, mathematics self-concept is reciprocally correlated with mathematics anxiety (Ahmed et al., 2012; Rossi et al., 2022), such that students with high mathematics anxiety tend to have negative mathematics self-concept.

Despite factors such as mathematics achievement, gender stereotypes and mathematics anxiety, there are few and contradictory studies that have focused on the socio-economic status, hence the current study explores the degree to which socio-economic status predicts mathematics self-concept. The literature does not depict adequate and conclusive information on the correlation between socio-economic status and mathematics self-concept. For example, Li et al. (2020) found out that socio-economic status and mathematics self-concept are positively and statistically significant correlated. As a result, students from well-resourced families with high socio-economic status tend to have high and positive mathematics self-concept. Contrarily, Malik et al. (2017) suggest that there is no statistically significant correlation between mathematics self-concept and parent's socio-economic status. In essence, in some instances mathematics self-concept remains the same regardless of family economic hardships and background. Henceforth, the correlation between mathematics self-concept and parent's socio-economic status remains inconclusive, contradictory, and further research is necessary.

LITERATURE REVIEW

For this study, the literature review consisted of the background of both mathematics self-concept and parent's socio-economic status. The review of literature starts with general self-concept, its background and models that are related with the formulation of mathematics self-concept. Furthermore, the background of parent's socio-economic status and the models associated therewith are discussed. Lastly, the correlation between socio-economic status and mathematics self-concept was reviewed.

Background of self-concept

Rogers (1959) argues that self-concept is how a person behaves, acts and perceive themselves and the world. These perceptions are normally shaped by personal experiences and their interpretations thereof. Despite that self-concept, can be traced back to 1600s (e.g., Descartes, 2017), it was only in 1976 that ambiguities were observed from the definitions of self-concept (Shavelson et al., 1976). The common definition was therefore accrued from diverse definitions that self-concept is one's perceptions about themselves and abilities and it is influenced by factors such as culture and society (Shavelson et al., 1976). Amongst other things, Shavelson et al. (1976) suggested that self-concept is hierarchical, with general self-concept split into academic, social, emotional, and physical self-concept. Furthermore, academic self-concept is split into domain specific subjects such as mathematics self-concept, English self-concept, science self-concept etc. This study focuses on mathematics self-concept

Models related to the development of mathematics self-concept

The development of mathematics self-concept can be closely linked with Internal/ External (I/E) frame of reference model, Skills Development (SD) model and the Big-fish-little-Pond effect (BFLPE) model. I/E model originates from the views Hebert Marsh (Marsh, 1986). I/E model posits that students develop their mathematics self-concept based on frames of references such as social (external) and dimensional (internal) comparisons (van der Westhuizen et al., 2022). According to social comparison or external frame of reference, students compare their mathematics performance and numeracy levels with other learners in the same grade (Wolff et al., 2018). When a student performs relatively or significantly higher than other students, that often boosts their confidence and consequently enable them to formulate positive and high mathematics self-concept. On the other hand, when a student performs worse than their peers, they tend to doubt their abilities in mathematics and further develop negative self-concept. As per dimensional or internal frame of reference, a student compares his performances in different subjects e.g., Mathematics and Science. A student may still develop a positive Mathematics self-concept even if their mathematics achievement is bad when compared to other students (social comparison), if his performance in mathematics is relatively higher than his performances in other subjects (Kavanagh, 2020). Summarily, I/E model depicts the extent to which students may develop their mathematics self-concept by social and dimensional comparisons.

One of the most prominent models that explain the development of mathematics is the Skills Development (SD) model. SD model originates from the views of Calsyn and Kenny (1977). This model posits that mathematics achievement is a strong predictor of mathematics self-concept (Preckel et al., 2017). Performing well in mathematics helps the students to improve the way they perceive their abilities in mathematics and that results in high mathematics self-concept. When this model is applied, the primary narrative is that teachers should implement strategies, systems and approaches that intend to derive good mathematics scores with the intentions of enhancing students' perceptions about the subject and related careers. The last model to be discussed is BFLPE. This model was proposed by Marsh in 1984 (Koivuhovi et al., 2022). BFLPE posits that students construct their mathematics self-concepts by comparing their performances with peers and this comparison and conclusion thereof are heavily influenced by the environment and learning setting (Marsh, 1987). Equally capable students may develop high Mathematics self-concept when they are in less competitive learning environment than a competitive setting (Fang et al., 2018). The students tend to formulate their mathematics self-concept in reference to the peers in line with environment. For example, a highest student with an average of 60% from one school might be the worse student in a learning setting or school where all students get an average of 80%. Thus, the highest performing student may still develop negative mathematics self-concept when placed in a competitive school or environment. All these models propose that mathematics self-concept is constructed based on internal and external comparisons. Setting learning environment may mediate the extent to which comparison is being made. Additionally, mathematics achievements play a huge and significant role on mathematics self-concept structure.

Background of socio-economic status

Socio-economic status (SES) is the social and economic position or ranking of an individual or group (Sbarra & Whisman, 2022). SES is normal measured by three indicators such as family monthly average income, parents' occupation, and level of education (Taramsari et al., 2021). SES is an important predictor for health (Stormacq et al., 2019), academic achievement (Liu et al., 2020) and overall child development (Bradley & Corwyn, 2002). Parents and families with better financial capacity and reasonable levels of literacy tend to have good chances to invest adequately on child's development which may include education, health, and well-being. The SES indicators are correlated such that, having ` good qualifications or high level of education gives one a fair chance to be employed at good paying jobs and have financial stability to take of care of their families and children. The following two models which are Family Investment model (FIM), and Family Stress Model (FSM) can be used to explain the correlation between SES and mathematics self-concept.

Socio-economic models and mathematics self-concept

Family Investment Model postulates that family investment on child development is determined by socio-economic position (Vasilyeva et al., 2018). Families with relatively enough resources are able to invest on child's education and well-being. Unlike affluent families, disadvantaged families are struggling to afford basic needs due to economic hardships. As a result, children may value or perceive education adversely. Henceforth, children from low socio-economic backgrounds tend to have negative attitudes towards education and further develop negative mathematics self-concept as compared to their counterparts from well-equipped families (Li et al., 2020). Availability of resources plays a noticeable role to shape how children view themselves and the importance of education (Goldan et al., 2021). Parents with high SES tend to set reasonable high academic expectations for their children and fund those set expectations (Butler & Le, 2018). Academic expectations may assist to pace up child's academic achievements and lead to improved mathematics self-concept. Thus, students from well-off families tend to be more confident and perceive themselves more positively about education and mathematics in particular.

The Family Stress Model posits that families with low socio-economic status tend to succumb to economic pressure and that causes emotional instability which therefore leads to disruption to and/ or inconsistent parental involvement (Masarik & Conger, 2017). As a result, poor parenting and involvement may lead to child's behavioural issues and self-doubts. Socio-economic hardships impact the extent to which a parent may participate to invent support systems and improve/ sustain well-being of a child. Henceforth, students from disadvantaged families are normally compromised and are likely to develop negative mathematics self-concept. Both FIM and FSM explain the extent to which parent's socio-economic may predict Mathematics self-concept.

RESEARCH METHODOLOGY

This study adopted regression and correlation research designs of the quantitative approach. The quantitative research designs were used based on their ability to test relationship between variables. Furthermore, the study expected to yield the results that can be a true reflection of the district and where necessary be generalizable to a similar context, hence quantitative designs were deemed appropriate. Regression method is used to test the impact of independent variable on a dependent variable (Boateng & Abaye, 2019). In this study, the impact of parent's socio-economic status (independent variable) on Mathematics self-concept (dependent variable) was explored. Akoglu (2018) defines correlation research as the design that investigates the statistical relationship between two or more variables to test the level of significance. In the current study, the statistical relationship between Mathematics self-concept and parent's socio-economic status was tested.

Three hundred and fifty-one (351) participants were sampled from a population of all Grade 9 leaners in OR Tambo Inland District using stratified random sampling approach. The sample comprised of 171 girls and 180 boys from 6 schools (3 rural and 3 urban schools). The sample was classified by gender and school location prior random selection of participants. This was done to ensure that characteristics of the population are well represented.

A questionnaire was used to collect the data. The questionnaire consisted of three sections: Section A included personal or biological information such as gender, age, school location, Section B focused on the measurement of parent's socio-economic status using three indicators which are (i) parent's occupation or employment status, (ii) parent's level of education and (iii) family average monthly income and Section C measured mathematics self-concept using Likert scale questions. Participants had to choose an option statement (1. Strongly disagree, 2. Disagree, 3. Agree and 4. Strongly Agree) that best suits their perceptions about their Mathematics abilities. Statements such as, 'I am good in Mathematics', I enjoy solving Mathematics activities' were used to measure mathematics self-concept. The validity was tested in two ways: (i) a team of experts was requested to assess the validity of a questionnaire and the general overview was that the instrument measures what it is intended to measure and (ii) furthermore, the Pearson correlation test was performed to substantiate the measurement of the instrument's validity. Pearson correlation for all questionnaire items was above the critical value and p-value was below 0.05. Thus, the instrument was tested and found to be valid.

The reliability of the instrument was tested by Cronbach Alpha. The results reflected Cronbach Alpha at 0.933 which is way above acceptable reliability score of 0.70. Hence, the instrument was found to be reliable. All ethical considerations and protocols such as obtaining signed consent forms, anonymity, confidentiality, right to withdraw the participation were observed. IBM SPSS software was used to effect correlational and regression analysis. The following results were found.

Findings

Table 1:
Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.768[a]	.590	.589	6.50989

a. Predictors: (Constant), SES
b. Dependent Variable: MSC

Table depicts R^2 = .589. In essence, parent's socio-economic status constitutes 58.9% of mathematics self-concept. Almost 60% of mathematics self-concept is explained by or accounted for by socio-economic background of the students. This implies that socio-economic position is a strong determinant of mathematics self-concept.

Table 3 reflects that $p < .001$ and F (1.349) = 502.9. P-value is below .05 this shows that the regression model in table 1 is statistically significant. Parent's socio-economic status predicts mathematics self-concept, and the prediction is statistically significant. The following analysis shows correlation between the two variables of interest.

Table 3:
Correlations

		MSC	SES
Pearson Correlation	MSC	1.000	.768
	SES	.768	1.000
Sig. (1-tailed)	MSC	.	<.001
	SES	.000	.
N	MSC	351	351
	SES	351	351

Table 3 shows that r (349) = .768, and $p < .001$. This indicates a strong positive correlation between mathematics self-concept and parent's socio-economic status. This shows mathematics self-concept increases and varies according to the level of parent's socio-economic status. The following analysis shows the means scores of mathematics self-concept distributed according to socio-economic status.

Table 4:
Multiple Comparisons

Dependent Variable: MSC

	(I) SES Level	(J) SES Level	Mean Difference (I-J)	Std. Error	Sig.
Tukey HSD	Low SES	Med SES	-14.40690*	.73803	<,001
		High SES	-19.55714*	.90947	<,001
	Med SES	Low SES	14.40690*	.73803	<,001
		High SES	-5.15025*	.89983	<,001
	High SES	Low SES	19.55714*	.90947	<,001
		Med SES	5.15025*	.89983	<,001

*. The mean difference is significant at the 0.05 level.

Table 4 reveals that the mean scores of mathematics self-concept measured by socio-economic status: Low, Medium, and High were 32.0, 46.4 and 51.6 respectively. There was a significant mean difference in mathematics self-concept as measured by socio-economic status (Low/ Med SES, $MD = 15.4$, $p < .001$; Low/ High SES, $MD = 19.6$, $p < .001$; Med/ High SES, $MD = 5.2$, $p < .001$). Mathematics self-concept varied according to parent's socio-economic status and the variation in mean scores was statistically significant. The results are discussed as below

DISCUSSION OF THE RESEARCH FINDINGS

Mathematics self-concept is an important construct to be enhanced in order to achieve improved results in mathematics (Marsh, 2022). This concept is also linked with future mathematics-related careers. Some scholars propose that it is predicted by mathematics achievements while some endorse the significance of the social and dimensional comparisons as primary basis of the development. The current study reveals that above half of the mathematics self-concept is predicted by socio-economic status. These results replicate the findings of Li et al. (2020). In essence, students from well-resourced have high mathematics self-concept as compared to the ones from struggling families. The mean differences are statistically significant.

In consideration that Eastern Cape Province is dominated by schools in poverty-stricken communities (e.g., Ngumbela, 2021), this means that a relatively high number of learners might have negative mathematics self-concept due to their family's economic hardships. For example, according to National Senior Certificate School Subject Report (2021), in all nine provinces in South Africa, Eastern Cape is always the worse performing province in athematics. Socio-economic conditions in Eastern Cape may cause students to perceive themselves negatively in mathematics and that may lead to poor Mathematics exam results. It may therefore be vital for Department of Education in the province to establish sound programmes to enhance student's mathematics self-concept. The programmes may have to be inclusive and built on the basis that these students are from disadvantaged backgrounds. Future studies may investigate the extent to which other factors such as age, gender and school location mediates the impact of parent's socio-economic status on the development of mathematics self-concept.

REFERENCES

Ahmed, W., Minnaert, A., Kuyper, H. & Van der Werf, G. (2012) Reciprocal relationships between math self-concept and math anxiety. *Learning and individual differences* 22(3) pp.385-389, https://doi.org/10.1016/j.lindif.2011.12.004

Akoglu, H. (2018) User's guide to correlation coefficients. *Turkish journal of emergency medicine* 18(3) pp.91-93, https://doi.org/10.1016/j.tjem.2018.08.001

Arens, A.K. Frenzel, A.C. & Goetz, T. (2022) Self-concept and self-efficacy in math: longitudinal interrelations and reciprocal linkages with achievement. *The Journal of Experimental Education* 90(3) pp.615-633, https://doi.org/10.1080/00220973.2020.1786347

Boateng, E.Y. & Abaye, D.A. (2019) A review of the logistic regression model with emphasis on medical research. *Journal of data analysis and information processing* 7(4) pp.190-207, 10.4236/jdaip.2019.74012

Bradley, R.H. & Corwyn, R.F. (2002) Socioeconomic status and child development. Annual review of psychology 53(1) pp.371-399, https://doi.org/10.1146/annurev.psych.53.100901.135233

Butler, Y.G. & Le, V.N. (2018) A longitudinal investigation of parental social-economic status (SES) and young students' learning of English as a foreign language. *System* 73 pp.4-15, https://doi.org/10.1016/j.system.2017.07.005

Calsyn, R.J. & Kenny, D.A. (1977) Self-concept of ability and perceived evaluation of others: Cause or effect of academic achievement? *Journal of educational psychology* 69(2) pp.136, https://doi.org/10.1037/0022-0663.69.2.136

Chiu, M.M. & Klassen, R.M. (2010) Relations of mathematics self-concept and its calibration with mathematics achievement: Cultural differences among fifteen-year-olds in 34 countries. *Learning and Instruction* 20(1) pp.2-17, https://doi.org/10.1016/j.learninstruc.2008.11.002

Descartes, R. (2017) *Descartes: Meditations on first philosophy: With selections from the objections and replies* (1641). Cambridge University Press.

Erdogan, F. & Sengul, S. (2014) A study on the elementary school students' mathematics self-concept. *Procedia-Social and Behavioural Sciences* 152 pp.596-601, https://doi.org/10.1016/j.sbspro.2014.09.249

Fang, J., Huang, X., Zhang, M., Huang, F., Li, Z. & Yuan, Q. (2018) The big-fish-little-pond effect on academic self-concept: A meta-analysis. *Frontiers in Psychology* 9 p.1569, https://doi.org/10.3389/fpsyg.2018.01569

Goldan, J., Hoffmann, L. & Schwab, S. (2021) A Matter of Resources? –Students' Academic Self-Concept, Social Inclusion and School Well-being in Inclusive Education. In J. Goldan, J. Lambrecht & T. Loreman *Resourcing Inclusive Education*. Emerald Publishing Limited, pp.89-100.

Kavanagh, L. (2020) Academic self-concept formation: testing the internal/external frame of reference model, big-fish-little-pond model, and an integrated model at the end of primary school. *European Journal of Psychology of Education* 35(1) pp.93-109, https://link.springer.com/article/10.1007/s10212-019-00416-w

Koivuhovi, S., Marsh, H.W., Dicke, T., Sahdra, B., Guo, J., Parker, P.D. & Vainikainen, M.P. (2022) Academic self-concept formation and peer-group contagion: Development of the big-fish-little-pondeffect in primary-school classrooms and peer groups. *Journal of Educational Psychology* 114(1) p.198, https://doi.org/10.1037/edu0000554

Lee, C.Y. & Kung, H.Y. (2018) Math self-concept and mathematics achievement: Examining gender variation and reciprocal relations among junior high school students in Taiwan. *Eurasia Journal of Mathematics, Science and Technology Education* 14(4) pp.1239-1252, https://doi.org/10.29333/ejmste/82535

Li, S., Xu, Q. & Xia, R. (2020) Relationship between SES and academic achievement of junior high school students in China: The mediating effect of self-concept. *Frontiers in Psychology* 10 pp.2513, https://doi.org/10.3389/fpsyg.2019.02513

Liu, J., Peng, P. & Luo, L. (2020) The relation between family socioeconomic status and academic achievement in China: A meta-analysis. *Educational Psychology Review* 32(1) pp.49-76, https://link.springer.com/article/10.1007/s10648-019-09494-0

Malik, M., Fatima, G. & Abid, U. (2017) Secondary School Students' Socio-Economic Status, Mathematics Self-Concept, and Achievement Goal Orientations: A Correlational Investigation. *Bulletin of Education and Research* 39(1) pp.215-227, https://eric.ed.gov/?id=EJ1210306

Marsh, H.W. (1986) Verbal and math self-concepts: An internal/external frame of reference model. *American Educational Research Journal* 23(1) pp.129-149, https://journals.sagepub.com/doi/abs/10.3102/00028312023001129

Marsh, H.W. (1987) The big-fish-little-pond effect on academic self-concept. *Journal of Educational Psychology* 79(3) p.280, https://doi.org/10.1037/0022-0663.79.3.280

Marsh, H.W. (2022) Extending the reciprocal effects model of math self-concept and achievement: Long-term implications for end-of-high-school, age-26 outcomes, and long-term expectations. *Journal of Educational Psychology* 115(2) pp.193, https://doi.org/10.1037/edu0000750

Masarik, A.S. & Conger, R.D. (2017) Stress and child development: A review of the Family Stress Model. *Current Opinion in Psychology* 13 pp.85-90, https://doi.org/10.1016/j.copsyc.2016.05.008

Mejía-Rodríguez, A.M., Luyten, H. & Meelissen, M.R. (2021) Gender differences in mathematics self-concept across the world: An exploration of student and parent data of TIMSS 2015. *International Journal of Science and Mathematics Education* 19(6) pp.1229-1250, https://link.springer.com/article/10.1007/s10763-020-10100-x

Ngumbela, X.G. (2021) Unique Challenges of the Poverty Dilemma in the Eastern Cape Province of South Africa. *African Journal of Public Affairs* 12(1) pp.114-131, https://hdl.handle.net/10520/ejc-ajpa_v12_n1_a8

Niepel, C., Stadler, M. & Greiff, S. (2019) Seeing is believing: Gender diversity in STEM is related to mathematics self-concept. *Journal of Educational Psychology* 111(6) p.1119, https://doi.org/10.1037/edu0000340

Preckel, F., Schmidt, I., Stumpf, E., Motschenbacher, M., Vogl, K. & Schneider, W. (2017) A test of the reciprocal-effects model of academic achievement and academic self-concept in regular classes and special classes for the gifted. *Gifted Child Quarterly* 61(2) pp.103-116, https://doi.org/10.1177/0016986216687824

Rogers, C.R. (1959) A theory of therapy, personality, and interpersonal relationships: As developed in the client-centred framework. *New York: McGraw-Hill*, pp.184-256, https://www.scirp.org/(S(351jmbntvnsjt1aadkposzje))/reference/ReferencesPapers.aspx?ReferenceID=1569786

Rossi, S., Xenidou-Dervou, I., Simsek, E., Artemenko, C., Daroczy, G., Nuerk, H.C. & Cipora, K. (2022) Mathematics–gender stereotype endorsement influences mathematics anxiety, self-concept, and performance differently in men and women. *Annals of the New York Academy of Sciences* 1513(1) pp.121-139, https://doi.org/10.1111/nyas.14779

Sbarra, D.A. & Whisman, M.A. (2022) Divorce, health, and socioeconomic status: An agenda for psychological science. *Current Opinion in Psychology* 43 pp.75 78, https://doi.org/10.1016/j.copsyc.2021.06.007

Sewasew, D. & Schroeders, U. (2019) The developmental interplay of academic self-concept and achievement within and across domains among primary school students. *Contemporary Educational Psychology* 58 pp.204-212, https://doi.org/10.1016/j.cedpsych.2019.03.009

Sewasew, D., Schroeders, U., Schiefer, I.M., Weirich, S. & Artelt, C. (2018) Development of sex differences in math achievement, self-concept, and interest from grade 5 to 7. *Contemporary Educational Psychology* 54 pp.55-65, https://doi.org/10.1016/j.cedpsych.2018.05.003

Shavelson, R.J., Hubner, J.J. & Stanton, G.C. (1976). Self-concept: Validation of construct interpretations. *Review of Educational Research* 46(3) pp.407-441, https://doi.org/10.3102/00346543046003407

Stormacq, C., Van den Broucke, S. & Wosinski, J. (2019) Does health literacy mediate the relationship between socioeconomic status and health disparities? Integrative review. *Health Promotion International* 34(5) pp.1-17, https://doi.org/10.1093/heapro/day062

Taramsari, M.G., Moeini, S.R. & Kazemipour, S. (2021) Socio-Economic Status and Infant Mortality Rate. *International Journal of Health Studies* 7(1) pp.33-36, https://doi:10.22100/ijhs.v7i1.834

van der Westhuizen, L., Arens, A. K., Greiff, S., Fischbach, A. & Niepel, C. (2022) The generalized internal/external frame of reference model with academic self-concepts, interests, and anxieties in students from different language backgrounds. *Contemporary Educational Psychology* 68 pp.102037, https://doi.org/10.1016/j.cedpsych.2021.102037

Vasilyeva, M., Dearing, E., Ivanova, A., Shen, C. & Kardanova, E. (2018) Testing the family investment model in Russia: Estimating indirect effects of SES and parental beliefs on the literacy skills of first-graders. *Early Childhood Research Quarterly* 42 pp.11-20, https://doi.org/10.1016/j.ecresq.2017.08.003

Wolff, F. (2021) How classmates' gender stereotypes affect students' math self-concepts: A multilevel analysis. *Frontiers in Psychology* 12 pp.1-12, https://doi.org/10.3389/fpsyg.2021.599199

Wolff, F., Helm, F., Zimmermann, F., Nagy, G. & Möller, J. (2018) On the effects of social, temporal, and dimensional comparisons on academic self-concept. *Journal of Educational Psychology* 110(7) pp.1005, https://doi.org/10.1037/edu0000248

Practitioners' Corner

Student Academic Success in Linear Algebra in an Open Distance Learning Environment[10]

Apostolos (Paul) Giannakopoulos, University of Johannesburg, South Africa
Kakoma Luneta, University of Johannesburg, South Africa

ABSTRACT

Academic success in first year university mathematics in been problematic for decades and mathematics educators keep looking for the causes. What has been universally agreed, is that the theoretical and abstract nature of mathematics plays a role. A module on Linear Algebra at an Open Distance eLearning (ODeL) institution, was identified for investigation due to very high dropout and failure rates. This article concentrates on identifying the types of knowledge (e.g., procedural, conceptual, strategic, schematic and declarative) necessary for academic success in the subject. Using the literature, a conceptual framework is developed to classify students' answers into the various types of knowledge. The research question asks what types of knowledge contributes to academic success in Linear Algebra. Script analysis is used to answer the research question. The results showed that lack of the necessary declarative knowledge which forms the basis for the other forms of knowledge as well as procedural knowledge were the main causes of the resulting misconceptions and errors. It was established that students were more engaged in surface learning rather than deep learning that results in conceptual understanding and acquisition of conceptual knowledge.

Keywords: Linear Algebra, ODeL, types of knowledge, mathematics content knowledge, procedural knowledge, conceptual knowledge

INTRODUCTION

Linear Algebra has been recognised as an important field of mathematics due to its applications in other fields of mathematics such as differential equations, analysis and probability among others. It is also a basis for understanding many topics in physics, chemistry, biology engineering as well as economy (Çelik, 2015). Investigating academic success in Linear Algebra thus, cannot be dissociated from that of academic success in mathematics. Several researchers (Britton & Henderson, 2009; Doneveska-Todorova, 2014; Rensaa & Vos, 2018; Soylu & Işik, 2008) have also highlighted the inclination of mathematical acquisition to dependence on Linear Algebra. The fact that the nature of mathematics is one of abstractness and theoretical (Britton & Henderson, 2009) implies that the teaching and learning (T & L) of the subject employs a particular approach; its own psychology of learning. This was recognised

[10] Date of Submission: 17 January 2023

Date of Review Outcome: 11 July 2023

Date of Acceptance: 29 August 2023

by Richard Skemp (1987) back in the 1970s who introduced 'The psychology of learning Mathematics'. Other researchers also related the psychology of learning mathematics to linear algebra (Dorier & Sierpinska, 2002; Hillel, 2000; Sierpinska, 2000; Doneveska-Todorova, 2014). The researchers delineated that teaching that promotes deep learning as compared to surface learning encourages conceptual understanding. This approach to teaching mathematics thrives on students' acquisition of conceptual knowledge (knowledge of concrete and abstract concepts and their relationships) which is a synthesis of other forms of knowledge (e.g., procedural, declarative, schematic, metacognitive and strategic). Furthermore, very little research has been conducted on the effect of these different forms of knowledge in the learning of Linear Algebra in particular. This article asserts that we speak of knowledge of Mathematics we refer to conceptual knowledge with understanding. Conceptual understanding (relational understanding-Skemp, 1987) leads to conceptual knowledge which is the knowledge of the definitions and applications of the concept in varies situations and circumstance (Luneta 2015). Concept learning combined with principles that govern them leads to the structure of knowledge (Giannakopoulos, 2017; Skemp, 1987). Depending on how, when, why and where such knowledge is used, different names are assigned to it, such as procedural, declarative, conceptual, strategic and schematic. Combining knowledge with cognitive skills enables students to solve problems.
The study is part of a longitudinal research project conducted at an Open Distance Learning (ODeL) institution, to improve academic success. An Action Research approach was used. It was exploratory by nature as it aimed at establishing the types of knowledge necessary for the teaching and learning of Linear Algebra. Linear Algebra was chosen due to the high failure rates and the desire of the researcher to improve his instructional approach that results in optimised learning outcomes.

The specific research question that we attempted to answer is:

> What types of knowledge are required for first year students to excel in a Linear Algebra at an ODeL institution?

To answer this question, the following sub-questions were also important to address: it is necessary to answer the following sub-questions:

- What is the connection between the different types of Mathematics knowledge?
- Of the knowledges necessary to acquire mathematical understanding which was the most prominent among first year students studying linear algebra?

We envisaged that by identifying the types of knowledge students possess (or lack of it), the approach and the instruments used would serve as a diagnostic tool that can be used to improve learning outcomes. It is also important to note that these types of knowledge (or dimensions of knowledge as Krathwohl, 2002 calls it), declarative, conceptual, procedural, strategic, and schematic) are directly related to Bloom's (1979) taxonomy.

LITERATURE REVIEW

In the teaching and learning of Mathematics there is the teacher, the student, the environment and the content to be learned. As this study concentrates on the content to be learned, acquisition of knowledge depends on a number of factors. Research on Linear Algebra identified gender? sex, teaching style, and prior knowledge (Robert, 1017; Soylu & Işik, 2008), teaching and learning approaches, problem solving and self-efficacy (Ferryansyah, Widyati., & Rahayu, 2018; Murray, 2013; Orhun, 2012), cognition, attitude towards linear algebra, and student attributes (Ferryansyaand, et al., 2018). It has also been accepted by many researchers that the T & L learning of linear algebra is difficult for the teacher and the student alike (Britton & Henderson, 2009; Çelik, 2015; Dorier & Sierspinska, 2002; Ferryansyah et al., 2018R; Ferryansyah et al., 2018; Robert, 2017; Wood et al, 2002). Dorier and Sierspinska (2002) and Britton and Henderson, (2009) further assert that the difficulty lies on the nature of mathematics in general due to its abstractness and theoretical nature. Linear algebra tends to be difficult as it demands high levels of thinking due to its formal nature. Dorier (2002) called it the *obstacle of formalism* and teachers and students alike recognise formalism to be an obstacle to learning. Formalism demands the learning of concepts for conceptual understanding rather than computational algorithms driven by procedural knowledge (Britton & Henderson, 2009). The student is faced with a plethora of definitions, new symbols and theorems and has to operate wholly at an abstract level.

The formal nature of linear algebra is characterised by modes of description (language, such as geometric, arithmetic, algebraic) (Hillel, 2000) and these require certain modes of thinking that is characterised by cognitive flexibility, trans-object level of thinking, theoretical as opposed to practical thinking, analytic-arithmetic and analytic-structural modes of thinking (Dorier & Sierpinska, 2002: Sierpinska, 2000). Each mode of description can be associated with one or more modes of thinking (Donevska-Todorova, 2014). For a detailed discussion on these two modes the reader can refer (Dorier, 2002; Dorier & Sierpinska, 2002; Hille, 2000; Sierpinska, 2000). These modes of description and thinking assume that different types of knowledge exist in the cognitive structure. The successful learning of any new concept depends on the ability of the learner to connect the concept to the existing cognitive structure and presupposes that such a structure was formed from deep learning (relational) (Skemp, 1987), learning with understanding as opposed to surface or instrumental learning (Rensaa & Vos, 2018; Skemp, 1987). For Skemp (1987: 29) understanding means "to assimilate [something] into an appropriate [existing] schema". Accepting that learning of Linear Algebra's nature demands learning of concepts, concept formation and acquisition combined with principles give rise to structures of knowledge (Skemp, 1987). This knowledge mingled with cognitive skills on the make up the cognitive structure also known as conceptual structure. It is the conceptual structure that has evolved from conceptual understanding and appropriate application of concept definitions that are procedurally used to solve mathematical problems and linear algebra (Luneta 2015). In order to effectively teach and learn mathematics Krathwohl (2002) developed a two-dimensional model of knowledge dissemination and acquisition. One knowledge dimension deals with Bloom's revised taxonomy aligned to teaching and the other of knowledge dimension aligned to learning (Rensaa & Vos 2018; Shavelson, Ruiz-Primo & Wiley 2005).

In mathematics knowledge acquisition has been identified to occur at different levels and in different forms (Luneta 2015). Researchers have classified mathematical knowledge into forms or types namely - declarative, conceptual, procedural, strategic, schematic, conditional, metacognitive and situational (Rensaa & Vos, 2018; Rittle-Johnson & Schneider, 2015; Krathwohl, 2002; Shavelson et.al., 2005; Soylu & Işik, 2008)

We attempt to shed some light into the differences in the meanings given to the various types of knowledge. We start from a psychological perspective of mathematical knowledge acquisition as espoused by Skemp's (1987) who asserts that mathematical knowledge acquisition and development of concepts is from the lowest level to the highest abstraction level. Skemp (1987) states that a concept is acquired firstly at a low level, like the name of a concept (e.g., number 3, three) (surface learning). Through further abstractions the learner understands the concept and can apply it successfully to objects or item to mean or represent the number three. This knowledge of the concepts forms the *knowing that* level (Skemp, 1987: p. 115) which a number of researchers (Krathwohl, 2002; Rittle-Johnson & Schneider, 2015; Shavelson et.al., 2005; Soylu & Işik, 2008) called declarative knowledge (knowledge of facts, definitions, descriptions). This knowledge could be a word/ concept or a 'packet of concepts', called schema. The learning of concepts and their relationships to a point of defining and applying them to different situations gives rise to conceptual knowledge, which is defined as a connected web of knowledge, a network in which the linking relationships are as prominent as the discrete pieces of information (Hiebert & Lefevre, 1986; Rittle-Johnson & Schneider, 2015; Wang, 2015).

Conceptual knowledge is seen as an integrated and functional grasp of mathematical ideas (Kilpatrick, Swafford & Findel, 2001 cited by Rensaa & Vos, 2018) and does not have a linear sequential character like the procedural knowledge (Donevska-Todorova, 2014). From the declarative knowledge we derive an appropriate plan of action which we may call *knowing how* (Skemp, 1987: p. 115) and a number of authors (Donevska-Todorova, 2014; Rittle-Johnson & Schneider, 2015) called that procedural knowledge. Hiebert and Lefevre (1986: p. 3) define procedural knowledge as consisting of mathematical language and "rules, algorithms or procedures used to solve mathematical tasks" or knowledge of procedures, a series of steps, or actions to accomplish a goal (Rittle-Johnson & Schneider, 2015). At this point a controversy arises that Rittle-Johnson and Schneider, (2015: p. 1126) called it the '*concepts-first*' or '*procedures-first* approach. They concluded that the relationship between procedural and conceptual knowledge is bidirectional and called it the '*iterative view*'. That is, as conceptual knowledge increases it leads to increase in procedural knowledge and vice versa since the initial knowledge could be conceptual or procedural (Rittle-Johnson & Schneider, 2015). Other researchers (Donevska-Todorova, 2014; Rensaa & Vos, 2018) have aligned the two knowledges to Linear Algebra. For instance, Donevska-Todorova (2014) provide an example of procedures-first and explain that by carrying out the Gaussian algorithm by using one's a procedural understanding it can be applied to solving a system of linear equations or finding an inverse of a matrix, thus linking it to other concepts which in this context can be regarded as conceptual understanding. In another example procedural knowledge is necessary to calculate the dot product of two vectors according to formula and conceptual understanding is involved when the dot product is used to calculate projections of vectors and the trigonometric function cosine, so to interpret the obtained scalar geometrically.

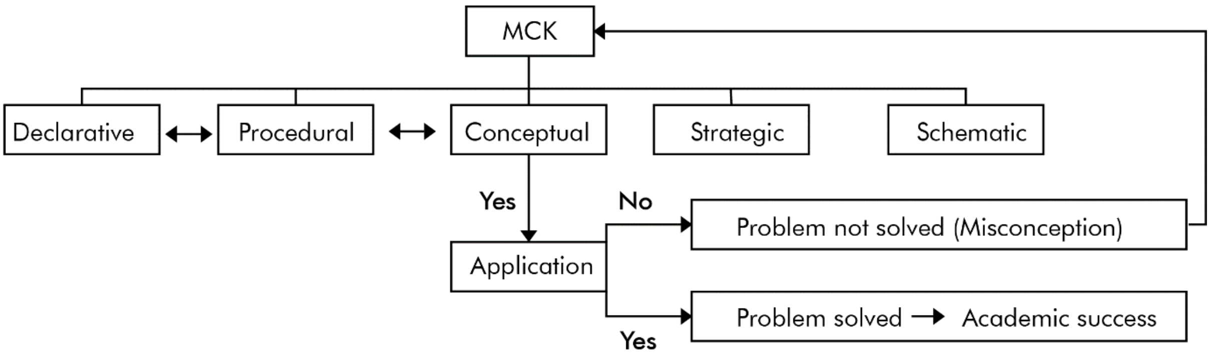
Rensaa and Vos (2018) stress that procedural and conceptual knowledge are related to students' learning and thinking and not to teaching and that conceptual knowledge confers benefits above and beyond having procedural skills. They further argue that linking procedural and conceptual knowledge provide computational shortcuts, ensure fewer errors and reduce forgetting. However, they warn us about confusing procedural knowledge with procedural fluency which is the result of conceptual understanding. On the other hand, conceptual knowledge could be superficial if it is constructed using weak schemas which are mainly related to primary level concepts. Renasaa and Vos (2018) further agree that procedural knowledge could be exhibited by the students if they have good mathematical skills in using formulae, algorithms and symbols, void of any understanding. However, interpreting and applying concepts, translating between verbal and visual and formal relationships such as the use of different representations in linear algebra is an indication of conceptual understanding. There are also misconceptions and errors that are associated with the acquisition of mathematical knowledge. Misconceptions result from lack of conceptual understanding, and they occur in the learner's mind and displayed as errors in spoken or written form by the learners (Luneta 2015). Luneta (2015) points out that misconceptions can result in several forms of errors (conceptual, procedural, practical, slipups/common mistake) depending on the severity of the misconceptions. Conceptual errors are those related to the lack of understanding of the concepts, resulting errors that show lack knowledge of the concept whereas procedural errors are errors related to use, adoption or display of wrong procedures and formula (Luneta 2015). Errors are therefore as a result of misconceptions.

The above exposition on declarative, conceptual and procedural mathematical knowledge highlights a very important aspect in acquisition of mathematical content knowledge. Declarative knowledge forms the basis of the other two types and the bidirectionality of conceptual and procedural is accepted by researchers such as Shavelson et al. (2005). But for declarative knowledge, schematic and strategic knowledge feature explicitly in research on linear algebra (Shavelson et al., 2005). The former deals with why we use certain concept (conceptual knowledge) or procedure (procedural knowledge). The latter deals with when, where and how the knowledge is used. For example, choosing the best procedure could save time in an exam, like a student who knows only to expand a determinant according to rows to apply it in a 5x5 determinant. Adding these two types of knowledge and using Shavelson et al. (2005)

conceptual framework we develop a new conceptual framework (see Figure 1) by connecting the types of knowledge to mathematical content and using the knowledge and various skills to solve mathematical problem. It is important to mention that,

Figure 1:
Mathematics content knowledge (MCK)

-



Shavelson et al. (2005) other than the dimensions of knowledge there is also the second dimension that of the 'extent', how proficient one is in any type or the level that the different types are acquired. In Figure 1, mathematics content knowledge comprises of different types of knowledge as identified by the literature. This knowledge is applied in solving problems. Successful application leads to academic success, while unsuccessful application (Luneta, 2015) implies misconceptions were formed during the use of one type of knowledge or the other. This framework forms the assessment instrument to analyse the existence or non-existence of one or more types of knowledge. It must be stressed here that the last two types of knowledge are not necessary to solve a problem but contribute to the quality of the solution. If we aim for deep learning, learning of concepts (concrete or abstract) should be goal-directed learning, learning with understanding (Skemp, 1987).

RESEARCH DESIGN

We attempt to develop a blueprint to answer the research question:

> What types of knowledge are required for first year students to excel in a Linear Algebra at an ODeL institution?

The literature review on the main constructs, reinforced the idea that the research problem is not only complex but that the interrelatedness between the constructs exacerbates that complexity. The research design then needs careful consideration so that the problem can be unpacked in order to solve it. Babbie and Mouton (2011) state that research designs usually fall into one of the three categories: Experimental, quasi-experimental, and non-experimental. These subsequently are divided into other sub-categories. In this particular case it is a non-experimental design. As it involves processing of marks from final examination scripts, the Quantitative method was followed. The data used was from students who sat for the final examination in linear algebra. In an ODeL education, where there are no face-to-face classes, all communication takes place either through electronic media (Learning Management System (LMS) (telephone, emails and pod casts). As a result, one way to assess students' performance is through their written responses to questions. The exam scripts were the primary data set and were used to capture students' mathematical knowledge, way of thinking, and problem-solving skills. Wood, Smith, Petocz and Reid (2002) state using examination results and scripts is practical and cost effective, objective and guaranteed quality assurance.

Data collection and analysis

The examination paper was divided into four questions, each question (Qi) covering a certain part of the syllabus. The concepts examined were: matrices/ determinants (Q1), linear systems (Q2), vectors (Q3) and complex numbers (Q4). Two sets of data were obtained. The first set, sample A, a purposive sample, comprised of the whole class of 26 students that sat for the final exam. This set of data assists us in forming an overview of the success rate of this class based on the numerical data obtained from the marks awarded to each student in the various questions of the examination paper and the concepts involved. Of the 35 students that were registered for linear algebra 5 dropped out and 4 did not qualify for the exam. Of the 26 that sat for the final examination 8 (31%) failed and only 1 re-registered. That meant the dropout rate in linear algebra was 37% (13 students) as 13 of the 35 students did not register in 2019.

The second set of data, sample B, also a purposive sample, aimed at identifying the types of knowledge demanded by each question. It comprised of 15 students and 5 scripts were randomly selected from 3 groups: Group A with an exam mark of 75% or more, Group B with a mark between 50% and 74% and Group C with a mark less than 50%. Students were assigned numbers 1-15 for ethical reasons (according to rank, thus student (5) refers to student number 5, ranked 5^{th}). This assists us to refer to the same student in different situations. The various questions and sub-questions were analysed and the different types of knowledge necessary to solve the problems were identified and tabulated.

We would like to explain here that different questions that assessed diverse types of knowledge were used to assess their existence on nonexistent in the students' answers. The five criteria used below were used and can be used in any part of mathematics. Combining research done on types of knowledge and research done on linear algebra, these criteria are all connected to modes of description and modes of thinking discussed in the literature review. Thus, various sections of the linear algebra paper used here are connected to either or both modes and the learning of mathematics in general.

1. Declarative knowledge (D) (facts/ definitions/ formula)
2. Conceptual knowledge (C) (correct application, transformations, proofs)
3. Procedural knowledge (P) (performing procedures correctly)
4. Strategic knowledge (St) (choosing the most appropriate method)
5. Schematic knowledge (Sc) (evidence that the student knows why a particular method was chosen).

After analysis of scripts, it became apparent that St and Sc were not prevalent in any question. Using the memo of the examination paper each necessary step is classified accordingly. It is possible that a step could contain one or more types of knowledge. Therefore, a new memo is developed using the types of knowledge. The validity and reliability of such a memo will depend on the correlation between the marks allocated by the two memos. In certain cases, adjustments can be made in the new memo to ensure the highest correlation, since the new instrument used is not an official way of marking, but it will be used as a part of a diagnostic tool to improve teaching practice.

The two sets of data that were collected contain sample A with the students' numbers and the total marks of each sub-question were recorded. Thus, we have sub-questions 1a, 1b, 1c, and 1d and so on. Then for sample B, each step of the memo was classified in terms of the types of knowledge involved to solve the problem. Thus, if in step 1 we need the formula u.v = a then a (D) is assigned. For calculation a (C) is assigned and so on. Descriptive statistics is used for process both samples followed by analysis of the students' answers.

The two sets of data are represented in Table 1. Table 1 shows the performance of students who sat for the exam with the top 15 achievers (Sample B (Avg, B, N=15)), and the percent of the group average, the median and the standard deviations were calculated. Then NS represents the number of students attempting a particular question followed by performance averages (Avg, P, D, C). Finally, the averages of sample A (Avg, B, N=26).

Table 1:
Students' performance in the examination paper (Samples A and B)

	Matrices/ Det/nants					Linear transf							Vectors					Compl.Nos					
Questions	1a	1b	1c	1d	Tot	2a	2b	2c	2d	2e	Tot	3a	3b	3c	3d	3e	Tot	4a	4b	4c	4d	4e	Tot
Avg.B,N-=15	3,7	4,1	6,2	8,1	22	4,7	4,4	2	1,6	2,7	15	4	4,3	2,3	4,5	4,1	18	2,7	5,2	4	1,4	4,4	11
%	98	87	94	96	94	100	67	40	24	89	62	85	77	83	84	64	78	79	87	48	57	30	48
Median	4	5	7	9	23	5	5,5	1	20	3	14	4,5	4,8	3	5	5	20	3	6	5	2	3	10
StdDev	0,8	1,6	1,8	1,8	3,8	0,6	2,9	2,2	45	0,7	5,5	1,5	1,9	1,2	1,3	2,2	6,2	0,7	1,9	1,8	0,9	4,2	9,1
NS	100	100	100	100		100	100	94	73	90		100	100	100	94	87		80	66	66	87	62	
%P	98	89	92	96	94	100	70	52	20	86	66	86	85	90	89	65	83	85	90	38		30	61
%D	97	84	95	90	92	100	71	48	31	84	67	84	79	91	90	60	81	90	86	60	57	32	65
%C	95	84	90	95	91	100	55	30	20	82	57	85	68	70	78	55	71	70	78	44		30	56
Avg (P,C.D)	97	86	92	94		100	65	43	24	84		85	77	84	86	60	78	82	85	47	57	31	60
Avg.A,N-=26	88	74	83	85	82	75	46	32	30	85	46	59	58	69	80	57	56	80	47	69	79	40	38

Performance in various questions by the class (Sample A)

For the whole class (sample A), students performed worst in Complex numbers (38%), followed by Linear Transformations (46%) then Vectors (56%) and last in Matrices/ Determinants performed best (82%). There were some sections where the students performed the worst, with averages ranging from 30% to 58%. For example, in the linear transformations section questions 2c and 2d dealt with proofs. No student that failed attempted these two questions). In question 2c (class average 32%) the students had to prove if A is a matrix and if $A^2 = A$ prove that det(A) = 0 or det(A)=1. For question 2d (class average 30%) students had to prove that two matrices are similar iff $A = PBP^{-1}$ where P is an invertible matrix and then prove that if A and B are similar then det(A) = det (B). In question 2b (class average 46%), the students were asked to find the determinant of a 4x4 matrix. Thus, 2c and 2d require both conceptual and procedural knowledge.

In the Vectors section students were asked to determine the dot product of 3-D vectors and the angle between them (question 3a, class average 59%), the orthogonal projection (question 3b, class average 58%) and the vector component if that vector is orthogonal to another. All students who attempted this question were successful as long as they knew the definition (formula) for an orthogonal projection (which is declarative knowledge). For question 3e where 3 points were given and asked to determine the equation of the plane passing through them, 87% attempted the question and averaged 67%. No student got 100% for this question. In the Complex numbers section, the class performed worst in the last question (4e, class average 40%) where a complex number is in standard form is given, and all the square roots must be calculated, and the answer must be in polar form. Here again P and C are involved. In question 4b (class average 46%) the students were given a Complex number in standard form, a +bi, to express it in polar form and another in quotient form to express it in the standard form. For question 1 (class average 82%) students performed worst in reducing a 4x4 matrix to row echelon form. Reduction to echelon form requires poor procedural knowledge.

Performance in various questions by the top 15 students (Sample B)

This group (sample B) was chosen to investigate the existence/ nonexistence of the types of knowledge by doing script analysis. This group's patterns of performance were mostly that of the class. For example, they equally performed worse in questions 2c and 2d (43% and 24%, respectively) and 4e (31%). In the other questions discussed above for the whole class this group performed relatively better. Having marked the papers according to D, C, and P, a 98% correlation was obtained between this method of marking and that of the official marker. It must be reiterated that this method of assessment is for diagnostic purposes and not for marking exam papers. Another interesting observation in Table 1 is the percentage of the students (sample B) that attempted some questions. The lowest occurred in Complex numbers and question 2d where they had to prove certain statements. The top 8 students attempted 100% of the questions. The standard deviations were relatively low (0,6 the lowest) and only in the question 4e it was more than 2,5.

Furthermore, the following criteria were used to analyse the scripts further.

1) For question 1 where the students performed very well question 2b was chosen which carried the lowest average mark and contains matrix/ determinant operations which are used in other parts of question 1 as well as in question 2, where similar errors appeared.
2) Questions 2c ,2d 3b, 3e, 4c, and 4e were chosen because the students performed the worst like the whole class.

It was decided to group the questions into various categories which shared common concepts. Examining the question paper, it was found that a number of questions (26%) (Group A) of the paper comprises of the use of a formula, substitution into the formula and performing operations. For example, use Cramer's rule, dot-product, angle between vectors, cross-product, area of a parallelogram, orthogonal projection, and the distance between two points. Performing operations on various concepts, e.g., matrix/ determinant operations, vectors and complex numbers was 32% (Group B). Involving formulae (D), performing operations (C) and following the correct path (P) is an indication that lack of any of the three, the problem cannot be fully solved. Two questions required the knowledge of the formula, knowledge of the procedure and performing of operations, e.g, the equation of a plane and find all square roots of a complex number (15% of the paper) (Group C). Use of an algorithm, e.g., finding the inverse of a matrix and converting a complex number in quotient form, solving simple linear equations with two unknowns made up 14% (Group D). Proofs made up 13% of the paper (Group E).

For Group A, the use of Cramer's rule is a good example to use. The student had to know the formulae to solve for x, y and z (D) which contains other concepts (the determinant and the determinants with respect to x, y and z. Needless to say if he/ she did not know the formulae he/ she could not answer the question. Not knowing how to calculate the determinants (P, C), the student again cannot solve the problem. Then another case with the dot-product when two vectors are given, and the student had to calculate the dot product. Student (14) did not know the correct formula (D) (e.g., he had divided by $||a||$ and not by $||a||^2$) but did know the procedure (P) and another student (5) who had to calculate the distance (D) between two points did not square the differences between the co-ordinates, but knew how to proceed to calculate the dot-product (P,C). Another student (2), although he/ she performed very well overall (85%) calculated the distance between two points as though the vectors started from the origin which could imply a careless mistake, or lack of conceptual knowledge.

It was noticed that in Sample A, most of the students that failed could hardly recall 20-30% of the formulae. Those that knew the formula (and how to calculate the other variables) achieved the highest marks which implies they possessed declarative, procedural, and conceptual knowledge. From sample B, the correct recall of formulae varied between 82% and 95% for this type of problems.

The results of this group support the ideas of a number of authors (Britton & Henderson, 2009; Donevska-Todorova, 2014; Skemp, 1987) that knowledge acquisition starts with the learning of concepts through initial abstractions which give rise to declarative knowledge. If these concepts are understood deep learning took place otherwise surface learning, which is accompanied by misconceptions (Luneta, 2015).

Understanding the relationships between the concepts and applying them implies that conceptual knowledge was acquired. Else misconceptions occur. Knowing how to perform operations between the concepts implies the student possesses procedural knowledge (Britton & Henderson, 2009; Donevska-Todorova, 2014; Krathwohl, 2002; Rittle-Johnson & Schneider, 2015; Soylu & Işik, 2008). The class performance in these sections was around 76% while the group performance (sample B) was around 84%.

For Group B, many students who could perform operations with 3x3 matrices/ determinants, when it came to 4x4 matrices/ determinants it appeared that what they thought if it was true for a 2x2 and 3x3 it will also be true for a 4x4. When the (square) determinants are especially of higher order (in this case a 4x4) in question 2b, where a 4x4 determinant was given many students failed to evaluate it. The student must also know alternative ways which could be shorter than expanding according to a row (column) (St). It was interesting to see only one student (2), to notice that the 4x4 determinant already contained 2 zeros in the first column and the subsequent 3x3 determinant also had two zeros. Most of the students opted for expanding rows. For example, student (8) performed row operations in the previous (Q1) correctly but with a 4x4 he/ she only operated with two columns the rest remained unchanged. Others applied the rules for a dot-product instead of the cross-product, while others obtained a vector from the dot product. In cases like these, it is evident that procedural knowledge in certain cases is not accompanied by conceptual knowledge thus one can say that procedural knowledge is in a fluid state. The class performance here was 72% while the group performance (sample B) was 80%. This above is another indication that may students lack either D or C or P

Groups C and D share the first part where an algorithm is similar to a procedure (Rittle-Johnson & Schneider, 2015). In the former case the student must know the algorithm how to convert a complex number in quotient form to standard form P and C) and in the latter how to construct the various vectors from given points to derive a formula for a plane in 3-D. Not knowing the procedure/ algorithm the student cannot answer the question. If the procedure is known, the student has to derive new information from the given information. The performance in these two sections was 90% for those that knew the algorithm or procedure and less than 10% for the rest. Of course, answers like the one given by student (4) where he/ she used the dot-product instead of the cross-product can confuse the researcher. It could be attributed to the fact that while the student had understood the dot-product he did not understand the cross-product (lack of C). For example, in question 3d where the question was to determine the equation of a plane given 3 points, and it requires the use of the cross-product he/ she also used the dot-product. How these two groups differ from the other two is that in Groups A and B, lack of declarative language leads to no solution to the problem. While in Groups C and D, lack of the procedure/ algorithm leads to no solution.

Finally, Group E deals with proofs (questions 2c, 2d). However even these proofs are not of high, abstract level as the questions were of the nature of a theorem in geometry. One does not need to understand the theorem, but you can still get full marks, if one can memorise the proof. Despite that, students as a whole performed worst (average 35%). In question 2c, the students had to prove if A is a matrix and if $A^2 = A$ prove that det(A) = 0 or det(A)=1as was stated above. The group average was 40%. For question 2d (group average 24%) students had to prove that two matrices are similar iff $A = PBP^{-1}$ where P is an invertible matrix and then prove that if A and B are similar then det(A) = det (B). Looking at students' answers became apparent that most students confused the properties of matrices with those of determinants or used numerical examples to prove a general case. For example, student (6) for the first question (2c) makes the assumption that matrix A is the identity matrix. This assumption was made by 70% of students who attempted this question. Another student (2) uses A as a 2x2 matrix with all elements equal to 1 and det(A) = 1. Student (8) states that since $A^2 = A$ then the matrices are identity matrices while student (13) uses an identity matrix and a matrix with elements equal to zeros and evaluates their determinant. Then in 2d, student (14) assumed that the all matrices are square matrices as a result it is possible that $PBP^{-1} = PP^{-1}B$ and the student cancels the Ps (as though $P.P^{-1} = P/P = 1$ and the student concludes A=B. Another student (3) (with exam mark of 77%) writes: Assume A=B then det (A)=det(B)!!! Student (2) (the second ranked with 81%) in the exam), multiplied both sides by P^{-1} and arrived at $P^{-1}A = BP^{-1}$ and concluded that A = B. Proofs here involve abstract conceptual knowledge mostly and some procedural knowledge, but all thought operations are abstractions on abstract objects. This falls in the algebraic mode of description (Donevska-Todorova, 2014; Hille, 2000).

From a linear algebra perspective, if we refer to the mode of description such as language and mode of thinking as identified in the literature (Çelik, 2015; Donevska-Todorova, 2014; Dorier & Sierpinska, 2002; Sierpinska, 2000) the content of the questions belong to the arithmetic mode and the required thinking is that of synthetic-arithmetic. However, vector spaces are involved here and are of very low level. The geometric mode features implicitly as students were not asked to represent any vector in geometric mode. Students who lacked conceptual knowledge showed that when they performed procedures such as row operations their approach was defective, though Çelik (2015) called them mistakes which in actual fact were misconceptions. However, as a whole where arithmetic thinking was involved the class performed well (76%) and the group (82%) compared to 68% of Çelik (2015).

The above discussion highlighted a number of problems that students encounter with acquiring the different types of knowledge which make the structure of knowledge of linear algebra. 73% of the paper followed the sequence of D→P→C (Groups A, B and C), 14% the sequence P→D→C (Group D) and C→D (Group E). This observation is in line with the literature (Krathwohl, 2002; Rittle-Johnson & Schneider, 2015; Shavelson et.al., 2005; Soylu & Işik, 2008; ;) where the *concepts-first* or *procedures-first* approach was used interchangeably (*iterative view*) on the types of knowledge where in some cases conceptual knowledge is developed from declarative and other cases from procedural. In abstract systems such as proofs, once understood, conceptual knowledge becomes declarative which is used to develop new conceptual knowledge through abstractions on abstract object (Rensaa & Vos, 2018; Skemo, 1987). The fact that success rate on the two proofs averaged the lowest (35%) is an indication that it is the most difficult part of linear algebra and was also highlighted by other researchers (Britton & Henderson, 2009; Dorier, 2002; Dorier & Sierpinska, 2002;).

Finally, using the types of knowledge to assess students' performance could be a valuable diagnostic tool that can be used for appropriate interventions. They can also be designed to improve pass rates. It gets its validity from the fact that this type of assessment correlates highly with the normal marking procedures. However, it should not be used as an assessment tool to assess examination papers because markers alone cannot be used to determine the different types of knowledge displayed by students.

CONCLUSION

The literature review has identified a number of factors that contribute to academic success in Linear Algebra. The studied literature indicated that conceptual and procedural knowledge is necessary to solve problems in Linear Algebra with little emphasis on declarative knowledge. Declarative knowledge forms the basis of the other two types. Schematic and strategic knowledge were not included as Linear Algebra problems require mostly declarative, procedural, and conceptual knowledge. This paper examined the types of knowledge as they are manifested in the final examination scripts of the students and the scripts were reassessed using the types of knowledge as an assessment instrument. Such an instrument can be of value to the teacher to improve his/ her teaching practice as it can be connected to Bloom's taxonomy as another dimension. Bloom's taxonomy is based on the depth of knowledge possessed by the student. By identifying the types of knowledge necessary to solve a problem (the length as suggested by Shavelson et al., 2005), it enables the teacher to be proactive and as a result students' misconceptions can be minimised. The analysis of students' answers indicated that students make too many assumptions (lack of conceptual knowledge). It can be concluded that although the examination paper contained predominantly declarative and conceptual knowledge, it cannot be divorced from the procedural knowledge in fact, declarative knowledge has been identified as the foundation of the other types, though it could be mere information acquired through surface learning. It was shown in the above analysis that lack of declarative knowledge leads to no solution to the problem. What distinguishes between the average and above the average students is the conceptual and procedural knowledge. And a final word for the lecturer: If you decide to teach procedures (procedural knowledge), ensure the procedures are understood (conceptual knowledge), while declarative knowledge must not be defective.

REFERENCES

Babbie, E. & Mouton, J. (2011) *The Practice of Social Research*. Cape Town: Oxford University Press Southern Africa.

Bloom, B.S. (1979) *Taxonomy of educational objectives. Book 1*. New York. McGraw-Hill, inc.

Britton, S. & Henderson, J. (2009) Linear algebra revisited: An attempt to understand students' conceptual difficulties. *International Journal of Mathematical Education in Science and Technology* 40(7) pp.963-974, doi:10.1080/00207390903206114

Çelik, D. (2015) Investigating Students' Modes of Thinking in Linear Algebra: The Case of Linear Independence. *International Journal for Mathematics Teaching and Learning* 3(1) pp.1-20.

Dorier, J.L. & Sierspinska, A. (2002) Research into the teaching and learning of Linear Algebra. In D. Holton (Ed.) *The teaching and learning of Mathematics at university level*. New ICMI Study. Dordrecht: Kluwer Academic Publishers, pp.255-273.

Dorier, H-L (Ed.) (2002) *On the teaching of Linear Algebra*. Dordrecht: Kluwer Academic Publishers.

Donevska-Todorova, A. (2014) *Three modes of description and thinking of Linear Algebra concepts at the upper secondary education*, https://eldorado.tu-dortmund.de/bitstream/2003/33447/1/BzMU14-4ES-Donevska-Todorova-55.pdf (Accessed 28 June 2023).

Ferryansyah, E., Widyawati. & Rahayu, S.W. et al. (2018) The analysis of students' difficulty in learning Linear Algebra. *Journal of Physics*: Conference series 1028 012152, doi: 10.1088/1742-6596/1028/1/012152

Giannakopoulos, A. (2017) Performance of Grade 12 Learners in Geometry. *Proceedings of the 23rd AMESA conference,* Nelson Metropolitan University, Port Elizabeth, South Africa.

Hiebert, J. & Lefevre, P. (1986) *Conceptual and procedural knowledge in mathematics*. Hillsdale, NJ: Laurence Erlbaum Associates.

Hillel, J. (2000) Modes of descriptions and problem of representation in Linear Algebra. In J-L. Dorier (Ed.), *On the teaching of Linear Algebra.* Dordrecht: Kluwer Academic Publishers, pp.209-246.

Krathwohl, D.R. (2002) A revision of Bloom's taxonomy: An overview. *Theory into practice* 41(4) pp.212-218.

Luneta, K. (2015) Understanding students' misconceptions: An analysis of final Grade 12 examination questions in geometry. *Pythagoras* 36(1) pp.1-11.

Murray, J. (2013) The Factors that Influence Mathematics Achievement at the Berbice Campus. *International Journal of Business and Social Science* 4(10) pp.150-164.

Orhun, N. (2012) The Relationship Between Learning Styles and Achievement on Linear Algebra Course. *Procedia-Social and Behavioral Sciences* 47 pp.638-642.

Rensaa, R.J. & Vos, P (2018) Interpreting teaching for conceptual and for procedural knowledge in a teaching video about linear algebra. *Skrifter från Svensk förening för matematikdidaktisk forskning,* pp.109-118.

Rittle-Johnson, B. & Schneider, M. (2015) Developing conceptual and procedural knowledge of mathematics. In R. Cohen Kadosh & A. Dowker (Eds.) *Oxford handbook of numerical cognition*. Oxford: Oxford University Press.

Robert, K. (2017). Factors Influencing Students' Academic Achievement in Linear Algebra. *International Journal of Education and Evaluation* 3(3) pp.18-23.

Shavelson, R.J., Ruiz-Primo, M.A. & Wiley, E.W. (2005) Windows into the wind. *Higher Education* 49 pp.413-430.

Sierpinska, A. (2000) On some aspects of students' thinking in Linear Algebra. In J-L. Dorier (Ed.), *On the teaching of Linear Algebra.* Dordrecht: Kluwer Academic Publishers, pp.209-246.

Skemp, R. R. (1987) *The psychology of learning mathematics*. London: Lawrence Erlbaum Associates.

Soylu, A. & Işik, A. (2008) Teaching Linear Algebra: Conceptual and Procedural Learning in Linear Transformation. *Educational Research Journal* 23(2) pp.203-226.

Wang, Q. (2016) Bridging the gap between declarative knowledge and procedural knowledge through metalinguistic corrective feedback. https://hdl.handle.net/2144/14568. (Accessed 10 January 2019).

Wood, L.N., Smith, G.H., Petocz, P. & Reid, A. (2002) Correlation between student performance in Linear Algebra and categories of a taxonomy. In *2nd International Conference on the Teaching of Mathematics (at the undergraduate level)*. Crete, Greece: John Wiley & Sons.

List of Reviewers,

Prof Piera Biccard, University of South Africa, South Africa

Ms Gloria Castrillon, University of Johannesburg, South Africa

Dr Martin Combrinck, Cape Peninsula University of Technology, South Africa

Dr Heather Goode, Da Vinci Institute, South Africa

Dr Reza Hosseini, The Independent Institute of Education, South Africa

Dr Matshemo Khumalo, The Independent Institute of Education, South Africa

Prof Derica Alba Kotze, University of South Africa, South Africa

Prof Tom Mackey (Editorial Board Member), Empire State University, United States

Mr Neil Manson, The Independent Institute of Education, South Africa

Prof Sioux McKenna (Editorial Board Member), Rhodes University, South Africa

Prof Karen Ferreira-Meyers (Editorial Board Member), University of Eswatini, Eswatini

Ms Martha Mosha, Independent Reviewer, South Africa

Mr Kevin Naidoo, Durban University of Technology, South Africa

Dr Kibbie Naidoo, University of Johannesburg, South Africa

Mr Wonga Ntshinga, The Independent Institute of Education, South Africa

Prof Elize du Plessis, University of South Africa, South Africa

Dr Clement Simuja, Rhodes University, South Africa

Ms Kelly Solomon, Rhodes University, South Africa

Prof Mahlapahlapana Themane, University of Limpopo, South Africa

Prof Alethea De Villiers, Nelson Mandela University, South Africa, South Africa

Dr Ria van Zyl, The Independent Institute of Education, South Africa