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International Association for Mobile Learning

22nd International mLearn/iTLT Conference

9-11 October 2023
The Capital Pearls,
Umhlanga, South Africa (Hybrid)

The Mobile Teaching & Learning Journey: Re-thinking our thinking and actions.

Conference Proceedings

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Mobile Learning

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Organised by

Faculty of Economic and Management Sciences

North-West University

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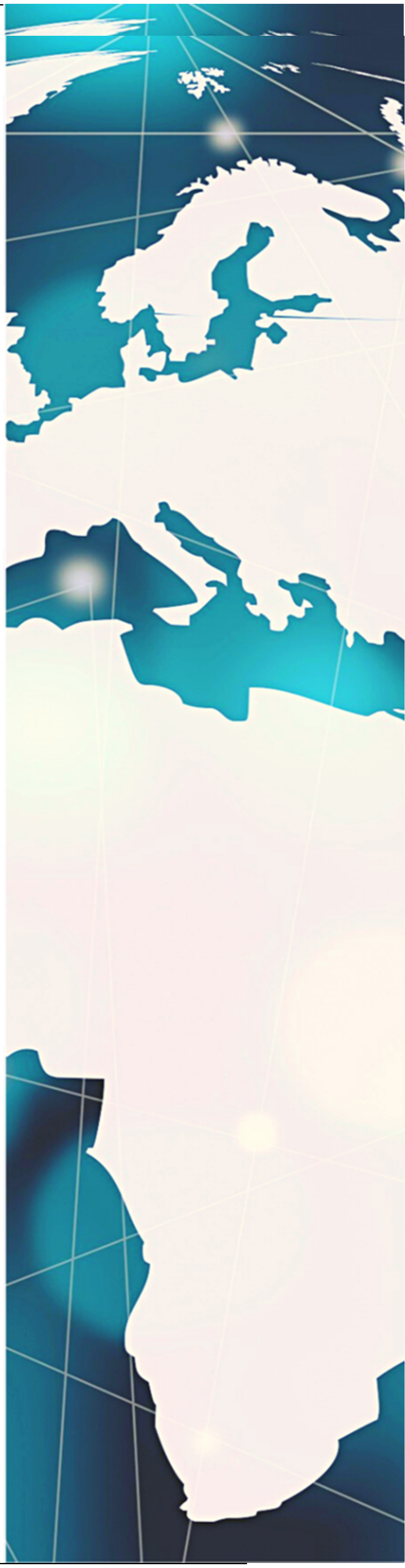

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PREFACE

Welcome to the 22nd World Conference on Mobile and Contextual Learning – mLearn 2023, hosted by the North-West University in beautiful South Africa. This event took place from 9 to 11 October 2023 at the stunning venue known as The Pearls in Umhlanga. Notably, mLearn 2023 also served as the grand introduction of the Faculty of Economic and Management Sciences' Innovative Teaching and Learning with Technology (iTLT) conference. This event offered a unique platform for Academic and Academic Support staff to converge, exchange their best practices, and unveil ground-breaking ideas and research.

The choice of The Pearls as our venue is symbolic of a new era dawning, of something new that will be emerging, where the innovative management and application of modern cutting-edge technology will revolutionise the landscape of education, ushering in a more pervasive and engaging learning experience. mLearn stands as the longest-standing international conference dedicated to mobile and contextual learning. South Africa proudly played host for the third time, marking the second occasion where we graciously welcomed this global gathering on SA soil.

The idea of the International Association for Mobile Learning (IAmLearn) was born in 2005 in Cape Town, and the IAmLearn, as a not-for-profit professional association, was registered in South Africa in 2008. Since then, it has grown into a globally recognised hub, fostering a tightly knit community of professionals and academics dedicated to advancing mobile and contextual learning. Our focus remains unwavering: promoting research, development, and application of mobile and contextual learning methodologies.

The overarching theme for mLearn 2023 was "The Mobile Teaching & Learning Journey: Re-thinking our Thinking and Actions." This theme encouraged retrospection on past achievements and set our sights on the horizon of new possibilities, building upon our collective successes.

The conference explored a diverse array of successes and opportunities, encompassing sub-themes such as:

- Stabilising T&L strategies after the Pandemic
- Tracking students' performance (Learning analytics)
- Big Data / data-driven learning
- Augmented reality/Virtual reality/Artificial intelligence (AI)
- Gamification
- Home-schooling
- Managing Technology in a T&L ecosystem
- Digital business strategies
- Creating Hybrid and Flexible T&L environments (HyFlex T&L)
- Podcasts and Micro-Videos for T&L
- Assessment

Two world-renowned scholars in the field, Mike Sharples and Donald Clark, delivered captivating keynote speeches, sharing their profound insights and experiences—looking back and reflecting on powerful ideas and disruptive devices and looking forward to creating new opportunities through artificial intelligence and pedAIgogy in higher education.

Our conference also featured engaging panel discussions, allowing delegates to participate in illuminating Q&A sessions with esteemed academics, enriching their professional growth. Additionally, post-conference workshops led by Donald and Callum Clark explored the use of podcasts and AI in education, equipping attendees with practical tools to innovate their teaching, learning, and assessment approaches.

The Organizing Committee of mLearn/iTLT 2023 extends heartfelt gratitude to the scientific review committee, external reviewers, session chairs, keynote speakers, panellists, panel facilitators, and dedicated administrative staff for their invaluable contributions to the resounding success of this conference.

We trust that this hybrid conference experience has been enlightening and fruitful, making significant strides in the realm of innovative teaching, learning, and assessment. Welcome to the future of education!

Herman J van der Merwe & Johan B Freysen
Conference Co-Chairs: mLearn/iTLT 2023

REVIEW PROCESS

The first call for papers went out early in December 2022, with a due date of abstract submissions by 27 March 2023. A database of possible reviewers was compiled by the mLearn-iTLT organising committee, indicating each reviewer's area of expertise. A total of 41 abstracts were submitted, and abstracts acceptance was communicated by 29 May.

The abstracts were blind peer-reviewed by national and international subject experts within their respective fields. Authors with accepted abstracts were invited to submit a full paper with a deadline of 21 July 2023. Five of the presenters opted not to submit a full paper but to do their presentation based on the abstract.

A total of 18 full papers were subjected to a double-blind peer review process. To avoid any possible prejudice, the papers were not reviewed by the same reviewers who reviewed a specific abstract, and care was taken to ensure that the respective reviewers were from different institutions and, where possible, from different countries. The identity and the institution of the reviewer remained anonymous. Where discrepancies occurred, a third reviewer was used. Where reviewers were authors of papers, care was taken to have these papers reviewed by reviewers from other institutions.

The list of reviewers is provided within the proceedings. Papers were reviewed according to the following criteria:

- Significance of the paper
- Originality
- Content including the abstract, quality literature review and/or research question.
- Appropriateness of research methodology
- Adequacy of results and discussion
- Technical, including language, spelling and references.

The authors received a reviewer report on the above-mentioned aspects and attended to comments and recommendations where needed. When required by reviewers, the author(s) submitted the amended paper and a change log. Both reviewers perused the revised manuscript and confirmed that they sign it off.

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Dr AZ Zhang	WEMOSOFT

PROGRAMME

Monday, 9 October 2023		
08:00 – 09:00	Delegate Registration	
09:00 – 10:00	**Venue: Royal Navy** **Chair: Prof Verona Leendertz** Welcome, Announcements: Prof Herman van der Merwe Keynote 1: Mike Sharples - **Powerful ideas and disruptive devices: An alternative story of educational technology**	
10:00 – 10:30	***Refreshments & Health Break***	
10:30 – 12:30	**Session 1: Venue Royal Navy: Session Chair Prof Helga Hambrock**	
	S1.1 (003)-T12	Re-thinking the use of a mobile invigilation app: Student experiences guiding future implementation (Van den Berg, L (Prof) – North-West University)
	S1.2 (004)-T12	Rethinking mobile device use in a fully online postgraduate diploma (Van Wyk, M (Dr); Wolff, E (Dr) – University of Pretoria)
	S1.3 (019)-T12	Designing assessments with mobile tours to improve academic integrity (Edmonds, RK (Mr); Manrique Clavijo, C (Mr); Burnett, S (Ms); Mills, A (Ms) - University of South Australia)
	S1.4 (024)-T12	AI – disruptor or catalyst for rethinking assessment (Kramm, N (Mr); Blackie, M (Prof) – Rhodes University, RSA)
	S1.5 (028)-T12	Evaluating the experiences and digital literacy of first-year students towards an e-Assessment platform (Nel, M (Prof); Paadi, KM (Dr); Chanza, MM (Prof) – North-West University, RSA)
	S1.6 (002)-T9	Moving away from traditional teaching – a case study of seamless learning (De Villiers, F (Dr), Ellis, W (Mr) – University of the Free State)
12:30 – 13:00	***Lunch***	
13:00 – 15:00	**Session 2: Venue Royal Navy: Session Chair Prof Belinda Gimbert**	
	S2.1 (015)-T11	Pe(e)rfectly Skilled: more proficiently skilled without a teacher? - Students' perceptions of (variants of) an online skills training method in Higher Education (Rusman, EM (Dr); Nadolski, RJ (Dr) - Open University of the Netherlands; Grevelink, N - Windesheim School of Applied Science, Netherlands)
	S2.2 (022)-T11	Exploring the Evolution of Mobile Learning: Insights from the mLearn Conference Series (2002 to 2022) (Koole, MLK (Dr) - University of Saskatchewan, Canada; MacCallum, KM (Prof) - University of Canterbury, New Zealand; Badarneh, NPB (Ms); Torres Callejas, EJT (Mr) - University of Saskatchewan, Canada; Chen, RC (Ms) - University of Canterbury, New Zealand)
	S2.3 (013)-T11	Mobile Learning in the Technical and Vocational Education and Training Sector: A Pedagogical Plus (Madambi, S (Dr); Ndamase, ZJ (Dr); Dawuwa, T (Ms); Gusha, N (Ms) - King Sabata Dalidyebo TVET College, RSA)
	S2.4 (036)-T11	Riding the high technology wave by implementing exemplary design strategies in a Human Anatomy course to strengthen student success (Hambrock, HB (Dr); Kristen, D (Mrs) - Sefako Makgato University of Health Sciences, RSA)
Panel Discussion	S2.5 (027)-T11	Leaping forward without losing sight of the past: A collective reflection on the future of mobile learning (Koole, ML (Dr) - University of Saskatchewan, Canada; Rusman, E (Dr) - Open University of the Netherlands; MacCallum, K (Dr) – academyEX, New Zealand; Cristol, D (Dr) - The Ohio State University, USA; Arnedillo-Sánchez, I (Dr) - Trinity College Dublin, Ireland; Van Der Merwe, H (Dr) – North-West University, RSA)
15:00 – 16:00	**Annual General Meeting**	

Tuesday, 10 October 2023		
08:00 – 08:30	Delegate Registration	
08:30 – 09:30	**Venue: Royal Navy** **Chair: Prof Herman van der Merwe** Keynote 2: Donald Clark - **Artificial intelligence (AI) in Higher Education will change everything!**	
09:30 – 10:00	***Refreshments & Health Break***	
10:00 – 12:00	**Session 3: Venue Royal Navy: Session Chair Dr Frelét de Villiers**	
	S3.1 (007)-T1	Moving beyond emergency remote eLearning: academic development principles for sustainability and stability (Van Ryneveld, L (Prof) – University of Pretoria; Greyling, FC (Dr) - National School of Government)
	S3.2 (011)-T2	Patterns of Learning Behaviours for Success in an Asynchronous Professional Training for Educators (Gimbert, B (Dr); Cristol, D (Dr); Men, Q (Mr) - The Ohio State University, USA)
	S3.3 (020)-T2	Enhancing student performance by adhering to adult learning principles (Du Preez, CP (Dr) – University of South Africa)
	S3.4 (017)-T3	A quantitative implementation and retention study of learning by mobile phone app (Juurlink, LBF (Dr) - Leiden University, Netherlands)
	S3.5 (021)-T3	Using Physical computing to crowdsource environmental data via the Internet of Things (MacCallum, K (Prof) - University of Canterbury, New Zealand; Parsons, D (Dr) – academyEX;)
	S3.6 (041)-T4	Challenges in the Implementation of Virtual Reality in Construction Education at a South African Institution (Harinarain, N (Prof) – University of KwaZulu-Natal, South Africa)
12:00 – 12:30	***Lunch***	
12:30 – 14:30	**Session 4: Venue Royal Navy: Session Chair Prof Dean Cristol**	
	S4.1 (035)-T5	Game design concepts applied to interactive activities to enhance mobile learning (Ștefan, IA (Dr); Gheorghe, AF - Advanced Technology Systems, Romania; Piki, (Dr) - University of Central Lancashire (UCLan Cyprus); Hauge, JB (Dr) - University of Bremen, Germany)
	S4.2 (033)-T5	Book Widgets as a gamification tool to support teaching and learning in Grade 5 (Van Wyk, M (Dr); Moodley, K (Dr); Anver Allie, S (Miss)– University of Pretoria, South Africa)
	S4.3 (034)-T7	Efficiently supporting parents within the diverse and unregulated home-schooling environment in the South African context using mobile technology (Freysen, SJ (Mr) - Commerce Edge Learning Innovation; Cox-Cronjé, R (Mrs); Cronje, C (Ms) – Brainline)
	S4.4 (012)-T9	An evaluation of a veterinary mobile record-keeping application in terms of usefulness and acceptance (Van Wyk, M (Dr); Van Ryneveld, L (Prof) – University of Pretoria)
	S4.5 (006)-T10	Framework for Digital business strategies for SMEs in retail sector in South African context (Muridzi, G (Dr); Dhliwayo, S (Prof) – University of Johannesburg)
	S4.6 (037)-T11	How can the mood of the mode be improved? An analysis of two research methodology courses based on the seamless learning design framework (SLED) to establish how course modes can be more effective (Hambrock, HB (Dr) - Sefako Makgatho University of Health Sciences; De Villiers, F (Dr) – University of the Free State, South Africa)
14:30 – 15:00	**CONCLUSION**	

KEY

#	CONFERENCE SUB-THEME	#	CONFERENCE SUB-THEME
T1	Stabilising T&L strategies after the Pandemic	T7	Home-schooling
T2	Tracking students' performance (Learning analytics)	T9	Managing Technology in a T&L ecosystem
T3	Big Data / data-driven learning	T10	Digital business strategies
T4	Augmented reality/Virtual reality/Artificial intelligence	T11	Creating Hybrid and Flexible T&L environments (HyFlex T&L)
T5	Gamification	T12	Assessment

The number between brackets refers to the original paper number, e.g. (006) refers to mLearn 2023-006

Wednesday, 11 October 2023		
08:00 – 08:15	Delegate Registration	
Workshop 1 — Venue: Royal Navy	**Chair: Dr Johan Freysen**	
08:15 – 10:00	**Using AI:** Donald and Callum will go through the practical approaches and tools one can use in AI for learning.	
10:00 – 10:30	***Refreshments***	
10: 30 – 12:00	**Workshop 1 (Cont.)**	**Free Workshop & Demo: Robotics and AI** **BY** Durban University of Technology
12:00 – 12:30	***Lunch***	
Workshop 2 — Venue: Teal	**Chair Prof Belinda Gimbert**	
12:30 – 14:00	**Podcasts for learning:** Having delivered a successful series of podcasts on learning theory and theorists, Donald will show why podcasts are so popular and how smartphone delivery is part of that story. He will call upon cognitive theory to explain both their popularity and application in learning. This will include researched advice on structure, style, and production.	
14:00 – 14:30	***Refreshments***	
14:30 – 16:00	**Workshop 2 (Cont.)**	

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mLearn 2023-004

RETHINKING MOBILE DEVICE USE IN A FULLY ONLINE POSTGRADUATE DIPLOMA

M. van Wyk
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University of Pretoria, South Africa

ABSTRACT
Since fully online courses are often designed with a laptop-using end user in mind, the frequent intuitive use of mobile devices urges learning designers to develop content that is mobile friendly. In this quantitative descriptive study, we used the Smura, Kivi, and Töyli (2009) mobile services usage framework to determine what mobile devices students prefer, which applications and connectivity (network) were being used, and what assessment activities students participated in when using a mobile device. Closed-ended Likert scale questions relating to the technical components, together with open-ended questions pertaining to challenges and recommendations for mobile device assessment usage, were included in a Qualtrics survey. By mapping the 253 students' intuitive use of mobile device responses, with the four technical components, the researchers were able to identify aspects that must be addressed in terms of enhancements for future mobile learning experience. The results show the preferred mobile device used for online learning, how network access was obtained and what online activities students participated in. Various challenges were mentioned. Knowing what mobile devices are used, through which networks LMS content is accessed, and for what kinds of assessment activities, informs the redesign of modules for mobile device usage while creating awareness of the limitations mobile device use has on students studying fully online.

Keywords: assessment; online learning activities; mobile device applications; mobile device usage; mobile device networks; mobile learning

1. INTRODUCTION AND BACKGROUND

When conceptualising, designing, and developing fully online postgraduate qualifications, the initial focus of the learning design team was on providing a value-laden curriculum with authentic learning experiences. Development decisions were mainly made with student users in mind, who access the learning management system (LMS) using desktop computers and laptops. With the first cohort of graduates having successfully completed the programme, the learning design team started prioritising the mobile learning experiences of the postgraduate diploma students, studying towards a degree in the field of health sciences. Students enrolling for fully online postgraduate degrees are often encouraged to have both personal computers and stable home wi-fi connections before enrolling in an online programme (University of Pretoria, 2020). In countries with lower levels of socio-economic standing, however, many students' resorts to mobile technologies for learning, due to a lack of resources required for web-based learning (Okai-Ugbaje, Ardzejewska & Imran, 2022). In addition, the use of mobile devices allows for convenient access to module materials (Milheim, Fraenza & Palermo-Kielb, 2021) and instant notifications and communication (Chang & Farha, 2021), however, several challenges stifle its uptake among students and higher education institutions.

Folger, Merenmies, Sjöberg, and Pyörälä (2021) raise the importance of facilitators knowing how to tailor courses for mobile learning, especially in terms of creating assessments for mobile completion. Similarly, Tong, Zhang, and Hu (2021) emphasise that mobile learning cannot merely be promoted for the sake of making content accessible, it should rather be designed to encourage the active construction of students' own knowledge systems through high-level thinking activities. As the use of mobile devices is promoted, training interventions on mobile learning should be made available to students and staff, while unique contextual considerations should be taken into consideration when making design decisions (Li, Lee, Wong, Yau & Wong, 2019).

This study, therefore, aimed to determine how and when students in a fully online postgraduate module used mobile devices in their weekly assessments. By better understanding their intuitive use, the learning designers, along with module facilitators could make informed design decisions that would positively impact planned student mobile learning experiences, unique to the students' online mobile learning contexts.

2. LITERATURE REVIEW

With the outbreak of the COVID-19 pandemic, various concerns arose with regards to students using mobile devices in online modules (Kaliisa & Picard, 2017; Milheim et al., 2021; Mohammadi, Sarvestani & Nouroozi, 2020). In a survey conducted by Wiley University surveys (n=3082), students increasingly indicated that they want to be able to use their mobile devices for some of their learning activities (51%), while 21% indicated they want to use mobile devices for all their module-related activities (Capranos, Dyers & Magda, 2021). This increased use of mobile devices confers with the results of the EDUCAUSE Horizon Report 2019 which states that mobile learning is one of the most important developments in educational technology in higher education (Alexander, Ashford-Rowe, Barajas-Murphy, Dobbin, Knott, McCormack, Pomerantz, Seilhamer & Weber, 2019). Students use mobile devices for ease of communication, speed of access to grades and schedules, and the comfort of reading, watching, or listening to digital materials at their own convenience (Capranos et al., 2021). The outcome of this survey was a plea to learning designers and lecturers to create mobile-friendly modules at universities (Capranos et al., 2021; Milheim et al., 2021).

A mobile device can be seen as any handheld device, such as smartphones, tablets, and e-readers (GCFGlobal, n.d.). These handheld devices have a few characteristics in common, namely portability, being small, and most often, they have the processing power of a laptop computer (GCFGlobal, n.d.). This definition resonates with what the authors of this study believe. In addition, mobile learning refers to learning that takes place using mobile devices, making learning possible anytime, anywhere, assuming a student has a stable internet or network connection (Singh, 2020). While mobile learning continues beyond the classroom walls, it also provides for self-paced learning, variations in content delivery, and ease of communication with peers and facilitators (Singh, 2020).

Pensabe-Rodriguez, Lopez-Dominguez, Hernandez-Velazquez, Dominguez-Isidro, and De-la-Calleja (2020) maintain that mobile learning systems should be easily usable, while taking into consideration user-related factors, such as applicability, satisfaction, and acceptance. In a study conducted by Gholizadeh, Akhlaghpour, Isaias, and Namvar (2022), further factors contributing to successful informal mobile learning uptake were user experience, app functionality, information conveyed, and value-add for users. In concluding their findings on mobile learning design, Al-Siyabi and Dimitriadi (2020) caution against cognitive overload and distractions. For learning institutions, however, aspects such as assessment integrity, while using a mobile device, is an essential component of mobile learning design (Godwin & Kelvin, 2023). Ensuring active learning and peer engagement on the mobile platform are further critical factors for student success in terms of achieving outcomes and enhancing motivations (Hsu, Chen & Hwang, 2023).

Since the first mobile smartphone was launched in 1992 (Tocci, 2023), students and lecturers have become familiar with their devices and applications, especially video-based social media applications (Al-Hunaiyyan, Alhajri, & Al-Sharhan, 2018). Milheim et al., (2021) found that students primarily use their mobile devices to engage with content and to communicate with facilitators, tutors, and peers. When combining all the student uses of mobile devices, students were found to use it to access the LMS, read announcements and check grades, submit assignments and complete quizzes, read online material, watch or listen to online lectures or videos, and to search for information (Kaliisa & Picard, 2017; Milheim et al., 2021). While students mostly email or text their facilitators, they use a variety of video conferencing applications, such as Zoom and Slack to communicate with their peers (Milheim et al., 2021).

In contrast to the work mentioned above, Stritto and Linder (2018) found that students participating in their study (n=2035), prefer not to use their mobile devices for accessing the LMS, and as little as 10% preferring to watch videos and engage in simulation and game-based activities. In their study, the students preferred to work with their laptops (Stritto & Linder, 2018). Venter, Van der Walt, and Swart (2015) reported that the functionalities of many LMS apps make mobile assessment completion challenging for students, thus discouraging their uptake of mobile learning. For many adult learners, mobile learning applications are experienced as highly complex to access and operate (Sabri, Gani, Yadegaridehkordi, Eke & Shuib, 2022). In addition, an ever-present obstacle for South African students is loadshedding, a form of planned electricity power outages or rolling blackouts, which force students to make use of costly mobile hotspots and internet cafes when participating in online studies (Cloete, 2022).

Al-Hunaiyyan et al. (2018) summarised the mobile learning challenges experienced by students and academics, as relating to: 1) change management; 2) educational, interface, and visual design; 3) technical issues, such as installation, support, internet, and electricity; 4) evaluation of both the learning outcomes and mobile devices; and 5) social-cultural challenges that refer to the accessibility and functionality of devices. Further, Crompton (2013) added: 6) data privacy; and 7) financial issues to the list of challenges.

Still, students have proven to be surprisingly self-efficient when it comes to the use of mobile devices for learning purposes, often making use of these tools intuitively. Odede (2021) reported that particularly undergraduate students perceive m-learning very positively, showing high confidence levels due to their frequent use of social media tools on mobile devices. Students with digital literacy, the ability to access, have meaningful use, and evaluate digital resources, are particularly well equipped to adopt mobile learning, if attention was paid to pedagogical design decisions made by the learning design team (Moya & Camacho, 2021). With these contrasting results, the researchers of this study could not ignore the influence of mobile device use in online postgraduate qualifications and therefore, asked the question: "To what extent are students intuitively using mobile devices in a fully online postgraduate diploma?" To investigate this question, the technical component layer of the mobile services usage framework developed by Smura et al. (2009) mobile services usage framework was used.

2.1 Theoretical framework

Since several frameworks propose various constructs for mobile device analysis (Benkhelifaa, Thomasa, Tawalbeh, et al., 2016; Kekolahti, & Karikoski, 2013), the framework proposed by Smura et al., (2009) for analysing the usage of mobile services was adopted. The researchers required a framework that would holistically look at mobile usage holistically, in terms of the different device types, networks used for connectivity, content engaged with, and applications used, given that very little was known about students' intuitive use of mobile devices for online learning purposes, at a traditionally contact university. The Smura et al., (2009) framework consists of two layers, namely measurement points and technical components of mobile use. As this study was from the end user's viewpoint only (one of the measurement points), the four technical components Device, Application, Network, and Content (Figure 1) were used as a lens to investigate the technical components of mobile device usage in a fully online postgraduate diploma (Smura et al., 2009).

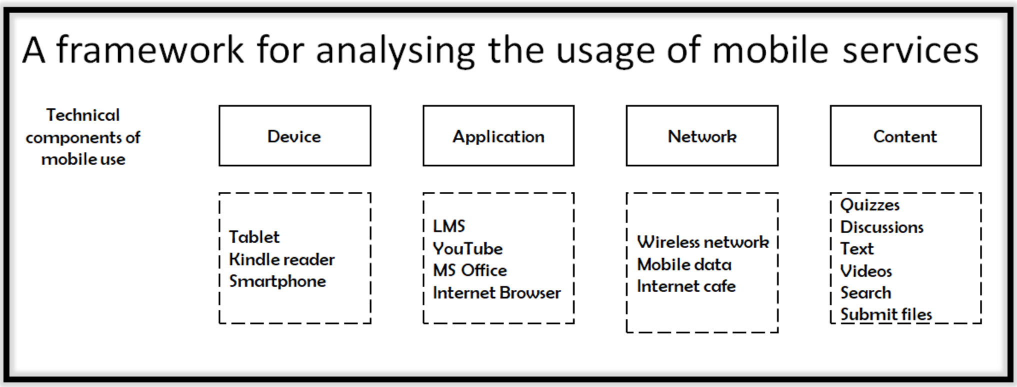

Figure 1. Framework for analysing the usage of mobile devices (Smura et al., 2009)

For this study, a mobile device is defined as a handheld device connecting to the internet with wireless communications (GCFGlobal, n.d.). The devices in this study refer to the various mobile devices that students typically use for convenience purposes. Therefore, during data gathering, the students could choose answer options between tablets/iPad, smartphones/iPhone and kindles/eBook reader or there was an option to select other and indicate a device the researchers were not cognisant of. Although a laptop could also fit the definition of a mobile device, it was excluded from this study (Wigmore, 2017).

Mobile devices support a wide variety of software applications, such as social media, communication, and time management apps (Ventola, 2014) and have since the late 90s, supported functionalities such as internet access, searching for websites and information, and video and audio capabilities (Smura et al., 2009). The applications investigated in this study relate to those that students are expected to use to participate in, and successfully complete any of the online modules (regardless of the type of device used). In the survey, the students could choose from application options including accessing the LMS (content retrieval, communication), Internet browser (search for or access content), YouTube (multimedia), and MS Office (typing of assignments and creating presentations).

The network component for this research refers to the connectivity and data usage of the mobile devices (Smura et al., 2009). As most Africans own mobile devices (77%) (Statscounter, 2023), only wireless connections, mobile data, and the use of Internet cafes were considered. The students could choose between wireless connections and mobile data, either at home, at work or Internet cafes, to convey how they accessed networks for mobile learning.

Finally, in the framework, content relates to the applications component and refers to the content of the activity's students are using the mobile device for. Possible options include answering quizzes, participating in discussion forums, reading text, watching videos, recording videos, searching for information, and submitting files (Ahmed, 2017). A link exists between the content and network constructs, since content is shared through the network components (Smura et al., 2009).

By mapping the student use of mobile devices with these four technical components (i.e., Device, Application, Network, and Content), the researchers were able to identify aspects that need to be addressed to enhance future mobile learning experience (Smura et al., 2009).

3. METHODOLOGY

In this study, the researchers were curious to know what mobile devices (device) and connectivity (network) students are using during their online studies. Further important aspects were to determine how postgraduate diploma students use the mobile devices (application and content) and what challenges they have been experiencing. Investigating the intuitive mobile use by online students was deemed important, since not only the researchers, but also their fellow learning designers and module coordinators needed to determine what adaptations were required to each module, so that students can experience mobile learning as valuable, accessible, and enriching. A quantitative research approach was adopted (Creswell & Creswell, 2018).

3.1 Research design

To determine to what extent students intuitively used mobile devices in fully online modules, a descriptive Quantitative cross-sectional study using survey research was done (Baker, 2017). Descriptive survey research is often used to investigate respondents' behaviour (MacDonald CM, Hancock, Kennedy, MacDonald SA, Watkins & Baldwin, 2022), such as 'what' mobile devices students use and for what assessment activities. Surveys are distributed to entire populations.

3.2 Sampling method

Probability sampling was used to select participants for this study. Stratified sampling was used to target a subgroup of the fully online postgraduate diploma population that were all registered in the same module. All students who had completed at least two online modules and were enrolled for the current module (HCM710), were contacted to complete the survey (Bloomfield & Fisher, 2019). After ethical clearance was obtained, students were invited to participate, therefore, a voluntary sample of 253 (from 268 responses) agreed and gave consent to participate in the current study.

3.3 Data gathering instruments.

An anonymous online survey was created on Qualtrics and distributed via a link to the students. The survey contained nine questions that relate to the student's mobile use. Seven of the questions were close-ended questions while two were open-ended questions. For five of the close-ended questions, students needed to rate their answers from Strongly Agree to Strongly Disagree (Likert scale). The open-ended questions related to the mobile app examples and the challenges students experienced while using mobile apps during the module.

3.4 Data analysis

The survey responses recorded were exported from Qualtrics to MS Excel. Pseudonyms P1-P253 were added to the data and the Likert scale responses were summarised in MS Excel using descriptive statistics. The open-ended questions were analysed using content analysis, to assign codes, search for emerging categories, and to identify themes that relate to the technical components of the framework for analysing the usage of mobile devices (Smura et al., 2009).

4. RESULTS AND DISCUSSION

The results of the study are discussed according to technical components for the mobile use layer of the framework for analysing the usage of mobile devices (Smura et al., 2009). These components are the Devices used, Applications used, Network accessed, and Content accessed. Demographical data of the full population will be discussed first, thereafter the results from the online survey will be presented.

4.1 Demographic data

To determine to what extent students intuitively use mobile devices in a fully online postgraduate diploma, a survey was distributed amongst 732 students registered in the module. Most of the students were African students (88%, *n*=642), followed by coloured (5%, *n*=36), white (4%, *n*=29), and Indian (3%, *n*=25). Although one student opted not to reveal their gender, the majority identified as females (81%, *n*=595), and the remaining students as males (19%, n=136). Their ages ranged between 25 and 62 years (mean = 35). From this population, 253 students (35%) gave consent and completed the online survey. As this part of the survey was anonymous, no personal details were collected from the sample.

4.2 Devices used

When asked to select all the mobile devices that students used during the completion of the 7-week online module (Figure 2), 232 participants (92%) answered the question. From the 232 participants, most used their smartphones (82%, *n*=191) and / or tablets (54%, *n*=126), while (some (12%, *n*=27) students indicated that they also used an eBook reader. When asking participants to provide a few examples of how they use the mobile devices for the weekly activities and assessments in this module, they indicated that they tend to favour their tablets instead of their smartphones. P187 summarised the opinions of other participants well, when explaining that tablets are more convenient:

> "*Blackboard on mobile was only used to check marks, it was difficult to watch the videos here because once the screen switches off, the video restarts instead of resuming. Blackboard on the tablet and PC were much easier to operate*" (P187).

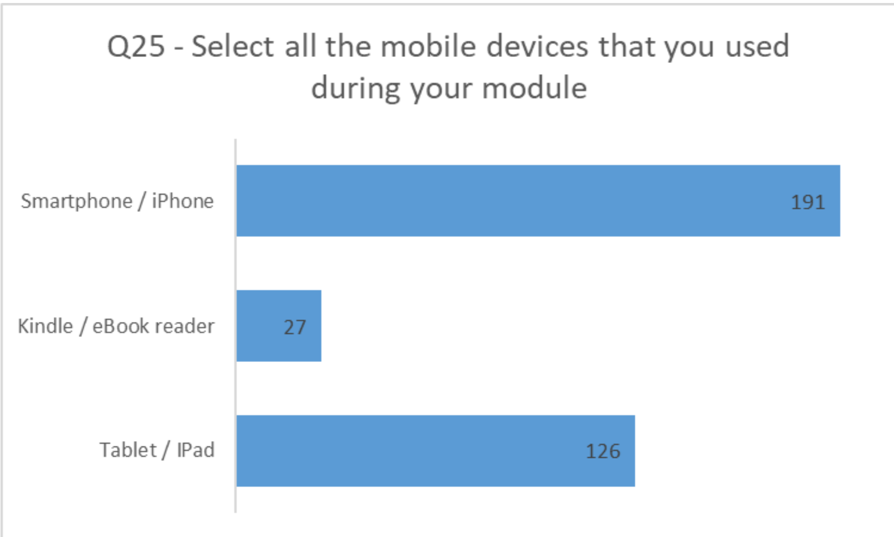

Figure 2. Selected mobile devices.

Although researchers such as Stritto and Linder (2018) reported that most students do not want to use their mobile devices for many of their online activities, the responses in this study (Figure 2) are contradictory. Of the 253 students, only 37 (15%) participants specifically mentioned that they "did not use any mobile devices for activities" (P106). The remaining number of intuitive mobile device users are reflective of the findings from the study of Capranos et al. (2021), where students wanted to use their tablets and smartphones when studying online.

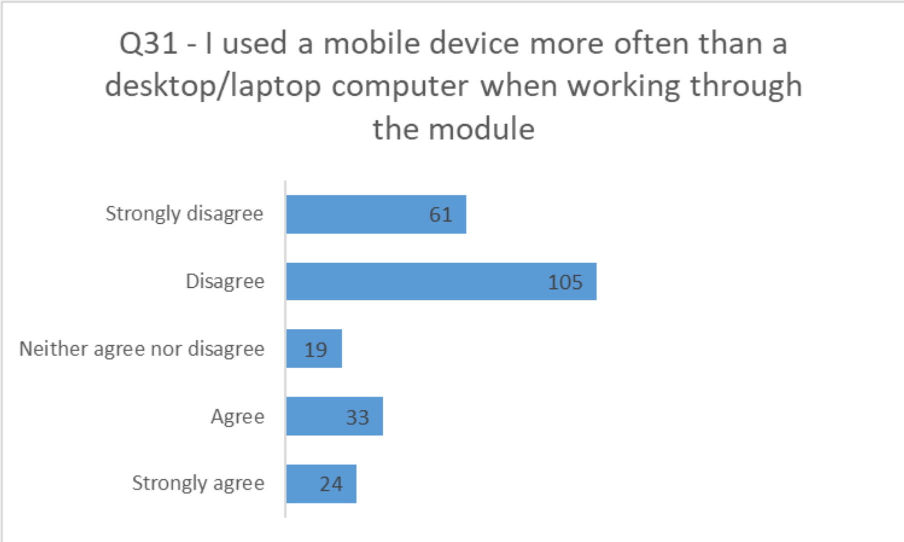

Figure 3. Laptop priority

Participants, however, confirmed that they generally preferred using their laptops above their mobile devices. Figure 3 reveals that participants disagreed (Disagree and Strongly Disagree) (69%) with the statement that they prefer to use a mobile device more often than their laptop / desktop computers. This was supported by the open-ended responses such as when P69 mentioned: *"I used my laptop most for work and phone for marks and announcements"* (P69).

4.3 Applications used.

Participants were asked to describe and give examples of the mobile apps they used during the completion of this module. The results are summarised in Figure 4. Based on the results, it is evident that the participants used their mobile devices for communication (WhatsApp, email, discussion boards), to access the LMS (Blackboard Learn, quizz), and for Internet searches (Google, Edge, Firefox). In addition, apps such as Google scholar (resources), MS Office (Word, PowerPoint) and YouTube (watching videos) were used for online learning. These examples relate to those discussed by Kaliisa and Picard (2017) and Milheim et al. (2021). Some of the participants revealed their preference for completing higher-stakes and more cognitively demanding tasks, such as assessments, using a laptop, while participating in more passive tasks, such as reading, video watching or discussions using mobile devices. P205 and P213 summarised the views of their peers well, by providing the following comments on app usage:

> *"I have however, used my tablet. Padlet and pictogram was done on the tablet."* (P205)
> *"Only used smartphone for group discussion and entire module I used my laptop."* (P213)

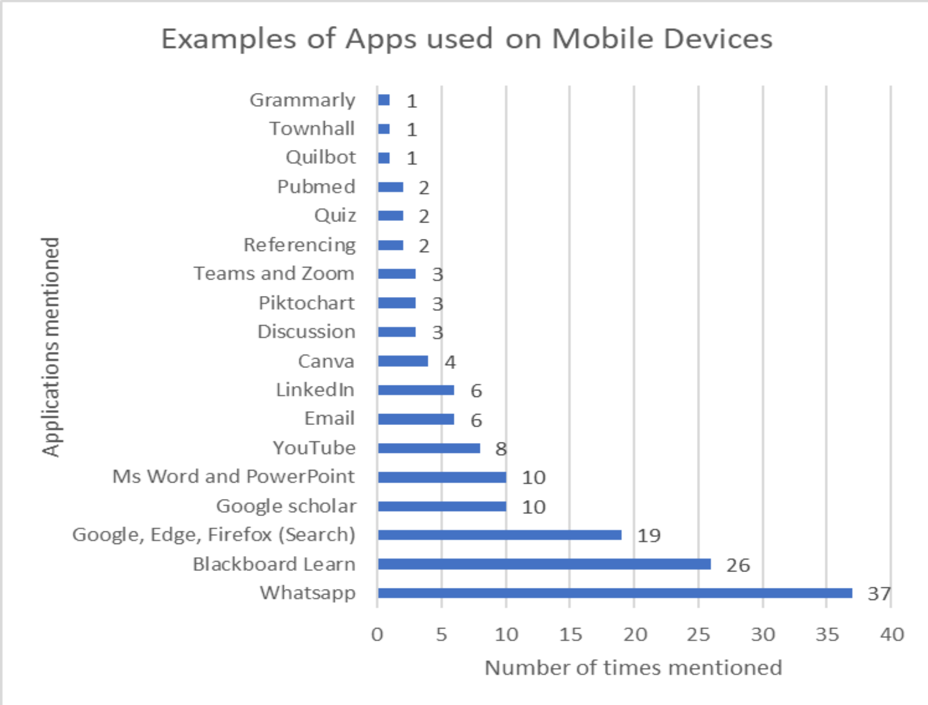

Figure 4. Mobile applications used.

From this study, it is encouraging to see that students are using a variety of apps on their mobile devices. P139 excitedly said *"Other than Microsoft office, my favourite has to be Canva for assignments that require a creative flair."*

4.4 Network used

Since this module forms part of an online qualification, it is a requirement that all students have stable Internet access. From the 253 participants, 241 (95%) answered the question; how students access the Internet. Participants indicated that they mostly access the Internet through wireless access at home (73%, *n*=175) or use their mobile data (68%, *n*=163). P146 indicated that they used their mobile device to *"create a hotspot"* (P146). A few participants used wireless networks at work (37%, *n*=90) or an Internet cafe (5%, *n*=12) as indicated in Figure 5.

Although the participants confirmed that they have Internet access as required, issues such as loadshedding (rolling blackouts) and cell phone reception hampered their progress. P17 mentioned "loadshedding and a lack of adequate network coverage" as possible challenges in completing the module (Cloete, 2022).

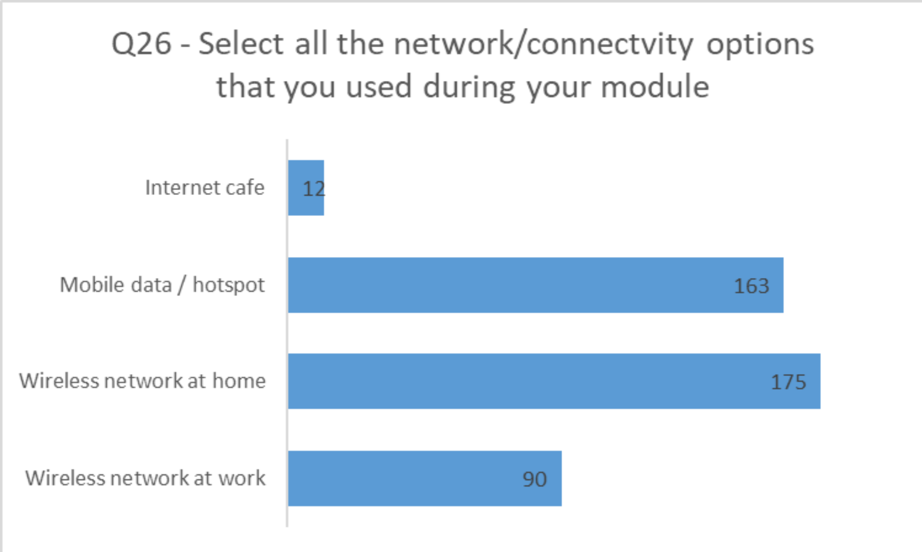

Figure 5. Network used for Internet access.

4.5 Content accessed through mobile devices

For the purposes of this study, content was defined as both learning materials (reading materials/text, watching videos and Internet searches) and assessment activities, such as quizzes, discussions, and assignments (Figure 1). To determine what module activities mobile devices are used for, students were asked whether they read their articles and watched the YouTube videos on their mobile devices, completed their quizzes, participated in discussions, or submitted assignments via their mobile devices. A summary of the students' responses is indicated in Table 1. From the results, it is evident that most of the participants agreed (Strongly Agree and Agree combined) that they used their mobile devices for reading articles and watching videos (64%, *n*=155). Open-ended responses revealed that participants used their mobile devices on a regular basis *"to check the work while I am on the go, [and] watched some of the videos"* (P227), *"check marks"* (P187), *"read articles and see content needed or provided for the week and the assignment requirements"* (P178). The views of P140 seem to aptly summarise that of their peers. *"For activities and assignments, I used a laptop, for reading and the videos, mobile phone and tablet are convenient"* (P140).

Participating in discussion forums had slightly lower agreement numbers, however, was still used by more than half of the students (50%, *n*=121). On the other hand, many participants disagreed (Disagree and Strongly Disagree combined) stating that they used their mobile devices for quizzes (59%, *n*=143) and assignment submissions (64%, *n*=154). Even though participants mostly indicated that they do not use their mobile devices for quizzes and assignments (Table 1), it is important for instructional designers and module facilitators to take note that a few of the students did indicate their agreement with using mobile devices for these content types (quizzes = 33% and assignment submissions = 29%). For example, P118 said that they used their mobile device *"to do my weekly activities in the evenings"*. In contrast with P118's success, P202 indicated that they tried but *"struggled with uploading assignments"*.

Table 1. Summary of content accessed and assessment activities

Content	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
Content (read / watch)	49	106	19	49	18
Quizzes	27	53	18	100	43
Discussions	38	83	24	69	27
Submit assignment	27	42	19	110	44

4.6 Challenges

The participants revealed that there were several challenges they faced when intuitively making use of mobile devices for learning purposes. Loadshedding (P17, P34, P51, P64) and lack of Internet connectivity (P3, P72) were mentioned numerous times as hampering participants' progress. P51 found that using a mobile device *"helped a lot during loadshedding"*, however, they still indicated experiencing great difficulty when attempting to connect with the Blackboard collaborate application using their smartphone. Blackboards collaborate was used intermittently for live virtual synchronous sessions called 'Townhall meetings' throughout the 7-week module.

Further challenges experienced in the Blackboard mobile app, were when trying to use discussion forums, submitting assignments, and doing quizzes. Participants struggled to see their discussion posts and specific threads in the discussion forums, resulting in them attempting to post, however, not being able to see their attempts displayed in the forums (P15, P31, P151). Participants also mentioned struggling with completing large assignments (P7) and uploading assignments (P202) when using mobile devices. Their struggle is evident in P204's remark that the mobile app did not display information fully. P204 explained: *"I did not use the mobile phone for this online module because in the previous modules I was missing a lot of information when it comes to assignments"*. In addition, P21, P156, P200, and P222 complained that they could not access the quizzes on the mobile devices. Participants, therefore, made recommendations that the facilitators change the quizzes so that it can be used on mobile devices (P163 and P220). P220 explained that they often worked outside the safety of an office, and for that reason, would rather not carry a laptop with them in the field, however, would appreciate being able to complete a quiz during their lunch hour, using their mobile devices (Singh, 2020).

> *"There are field workers in this course, if I am in the field/area doing inspections, I can use my 1-hour lunchtime to take a quiz and/ submit an assignment without opening a laptop that is probably much safer in the boot. I am referring to the mobile app, not the web-based application." (P220)*

Further, participants mentioned screen size as a challenge when attempting to engage with content on their mobile devices. P244 explained that they preferred not to conduct actual classwork on their mobile device due to its smaller screen size, while P23 complained that videos were too large for the screen. P205 explained that it was very difficult to make *"use of a screen reader when I was using the mobile device"*. While for P227, the small screen size resulted in physical discomfort, listing nausea as a direct cause of working on such a small screen size.

Additional challenges included the mention of external programmes that do not want to load (P2, P33, P246) and the Blackboard learn app's offline features that did not work (P15). One participant (P77) did not provide exact details, however, merely indicated that *"some other Blackboard features did not work"* on the mobile devices. P132 complained that *"many videos needed streaming, which caused a lot of mobile data costs"*.

5. CONCLUSION

When looking at the data through the lens of a learning designer, it is evident that mobile learning experiences need to be consciously planned for, when creating online content. In this study, at least 30% of students intuitively made use of their mobile devices to participate in learning activities. Therefore, consideration must be given to the devices, networks, apps, and content students use for mobile learning, as well as the challenges experienced. Since some of the challenges are beyond the control of learning designers, such as loadshedding, there are other aspects that can be improved on.

Higher education institutions can place pressure on LMS creators to constantly renew their mobile apps to ensure accessibility and a better student experience (Shanmugasundaram, & Chidamabaram, 2020). Learning designers could also explore additional apps (Gladman, Tylee, Gallagher, Mair & Grainger, 2021) to host quizzes and other assessments, especially given the successful use of a diverse number of apps by the student populus. Further, considering that 68% of the participants used their mobile data for Internet connectivity, attention must be paid to bandwidth requirements (Mei, Gou, Cai, Cao & Lui, 2022) for content created in online mobile modules.

From the students' perspective, it is evident that there is a need for accessible mobile learning resources and assessments, not only for convenience, but also for students' safety, when conducting fieldwork. The study found that when using mobile devices in the online module, students experience a disconnect between the module material and the compatibility of some of the learning devices (Milheim et al., 2021). Although the use of tablets was more successful than the smartphone, access to assessment activities pose several challenges. Students experience device design difficulties, such as small screen size, readability issues, and low connection speed (Kaliisa & Picard, 2017; Milheim et al., 2021).

Although devices have small screens, students could manage to access content such as readings and videos. Connectivity was mostly a problem due to loadshedding (rolling blackouts) (Cloete, 2022).

Applying the Smura et al. (2009) framework to this study provided the facilitators and learning designers with valuable insights on how students are using their mobile devices intuitively during a fully online postgraduate diploma. Knowing what devices and what kind of activities the students are using, informs the redesign of content and activities for mobile device usage. It also made the research team aware of what kind of limitations the mobile device use had on studying fully online. To be successful in the implementation of mobile learning, it is important for framework and policy developers to know the challenges experienced by students, so that these can be addressed in the implementation of mobile learning (Al-Hunaiyyan et al., 2018).

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FRAMEWORK FOR DIGITAL BUSINESS STRATEGIES FOR SMES IN RETAIL SECTOR IN SOUTH AFRICAN CONTEXT

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ABSTRACT
The concept of digital business strategies came into being for SMEs in the retail sector, through the convergence of business and IT strategies as a prerequisite for driving innovations and remaining competitive. This phenomenon constitutes a global paradigmatic shift for SMEs to survive and grow, which calls for a transition from traditional retailing models to industry 4.0 data-driven business practices by deploying a Digital Transformation strategy. Digital technologies are driving cost efficiency, providing new revenue opportunities, and changing business models in the retail sector. A digital demands and company needs a "digital business strategy", which is the only way to create new and adapted products, answer the changing customer demands, and avoid the disruption of traditional markets. Systematic literature review approach was used to establish and assess the current knowledge base that informed the development of a framework for digital business strategies for SMEs in the retail sector. A key factor of adequate searching was the identification of keywords using leading databases (Google Scholar and Science Direct). Overall, 115 articles had to be analysed to extract interesting insights. Showed that customer experience, data, platforms, competition, strategy, content, and innovation are the most important drivers and components of the Digital Business Strategies for the retail sector. Digital Business Strategies enables greater organizational efficiency and effectiveness through streamlined operations, enhanced resources as well as new capabilities for the retail sector. One of the fundamental areas for development is setting up an ecosystem through a framework for SMEs in retail sectors to develop their products further and tap into global markets. Digital Business Strategies is a business strategy that exploits digital technologies to create capabilities and responsiveness to ongoing environmental changes in retail business markets.

Keywords: SMEs; retail sector; digital business strategy; industry 4.0; innovation; transformation

1. INTRODUCTION

In South Africa, the small and medium retail enterprises are increasingly becoming important contributors to the economy. To ensure they remain competitive and sustainable in the digital age, it is important that these enterprises effectively harness the power of technology. Therefore, this article seeks to develop a framework for digital business strategies for SMEs (Small and Medium Enterprises) in the retail sector in the South African context. Recent advances in digital technologies, comprising information, computing, communication, and connectivity, have led to new opportunities for business model innovation (Bharadwaj et al.,2013), therefore SMEs in the retail sector should embrace these new opportunities. Digital Business Strategy (DBS) creates the foundation for digital business models. While managers from IT companies, such as Facebook, Google, and Apple, successfully utilize these technologies to form new global ecosystems, managers from traditional sectors including the retail sector often struggle to understand innovation logic that may deviate fundamentally from their previous knowledge. Hence, new digital business models have already changed the balance of power for sectors such as media and retail (Veit et al., 2014). The objective of this study is therefore to identify the Critical Success Factors (CSFs) of DBS in today's business environment and to develop a framework for digital business strategies for SMEs in the retail sector in the South African context.

Retail SMEs market is confronted with unprecedented challenges brought by digital era. The concept of digital business strategies came into being for SMEs in retail sector, through the convergence of business and IT strategies as a prerequisite for driving innovations and remaining competitive. Retail SMEs not prepared for a digitalized business model, and the actual digitalization process of the business model, not only changes the business rules but disrupts them with new possibilities (Fitzgerald et al., 2014; Gartner 2020a) within the background of a deep crisis which is triggered by online eCommerce competitors forces offline retail SMEs to digitalize or will die due to the continuously changing market (Safari et al., 2015).

Despite Industry 4.0 transforming manufacturing in terms of the way of producing and distributing goods by means of process digitization, the offline retail SMEs market is struggling to satisfy customers' shopping expectations due to two direct constraints: existing offline competitors operating under a narrowing market share, and online retail competitors increasing market share due to their better positioned eCommerce IT platforms (Gavrila & Ancillo, 2021). The process of change towards a digital business requires a specific strategy type, aimed to solve problems with uncertainty caused by Industry 4.0 implementation (Trzaska, Sulich, Organa, Niemczyk,, & Jasi ´nski, 2021).

The research gap identified in this paper is related to the lack of a framework that fuses different digitalization strategies with business models for SMEs in the retail sector. The review shows that academic research is lagging in contributing to digital business strategy for retail sector (Rockart, 1981). The paper also observed a scarcity in the scientific literature that explains the relationships between digital transformation and the retail sector. However, guidelines for the development of DBS along with effective implications for the design of digital business models are still scarce in the academic literature (Sia, Soh, & Weill,2016). This paper, therefore, proposed a framework for digital business strategies for SMEs in the retail sector in the South African context.

2. LITERATURE REVIEW

According to Davidson and Vaast (2010), digital business strategy is the search for opportunities based on the use of digital media and other information and communication technologies. Yaghoubi, Salehı, Eftekharıan, and Samıpourgırı (2012) emphasize that digital business strategy is a type of entrepreneurship involving digital products or services, digital distribution, a digital workplace, a digital market, or some combination of these. According to Rashidi, Saeid Yousefpour Yalda sani ve Shadi Rezaei (2013) digital business strategy is an area of entrepreneurship where new technological tools such as the internet and informatics are used for business. Digital initiatives are characterized by the intensive use of new digital technologies to improve business areas, invent new types of business, interact with customers and stakeholders, to create future business and growth opportunities (Eleftheriadou, 2014). This paper therefore seeks to develop a framework for digital business strategies for SMEs in the retail sector in the South African context for their growth.

Digital transformation and business strategy development allow organizations to adapt to their client's individual needs (Makieła & Kusio, 2021), follow the trends in the business sector, and to align with each other in the value networks (Niemczyk & Trzaska, 2018). These changes enable organizations to gain a competitive advantage (Gajdzik, Grabowska, Saniuk & Wieczorek, 2020) and possibly sustainability based on digitalization (Fernandez, Alves, Gaspar & Lima, 2021) and technology implementation (Borowiecki, Siuta-Tokarska, Maro ´n, Suder, Thier, & Zmija, 2021) called digitization. The business model concept is a useful lens for better understanding the business logic of a company by describing how value is created, delivered and captured (Osterwalder and Pigneur, 2010). A business model can be categorized as digital if digital technologies trigger fundamental changes in these value dimensions (Veit et al., 2014). Bowman and Ambrosini (2000) define value creation as a contribution to the end-users benefit of the product or service and distinguish it from value capture, which is the difference between revenue and cost generated by the company. Mol, Wijnberg and Carroll (2005) conceptualizes a section that accumulates over multiple value-added stages, often even in a general value proposition. Therefore, SMEs in the retail sector should enjoy fundamental changes in their value proposition if it accepts, use, and adopt digital business strategies and digital business models.

2.1 Drivers of Business Strategies

Bharadwaj, Sawy, Pavlou, and Venkatraman (2013) identified four key themes to guide our future thinking on digital business strategy and provide a framework to help define the next generation of insights. The four themes are (1) the scope of digital business strategy, (2) the scale of digital business strategy, (3) the speed of digital business strategy, and (4) the sources of business value creation and capture in digital business strategy. These four key themes feed into the proposed framework for digital business strategies for SMEs in the retail sector in the South African context.

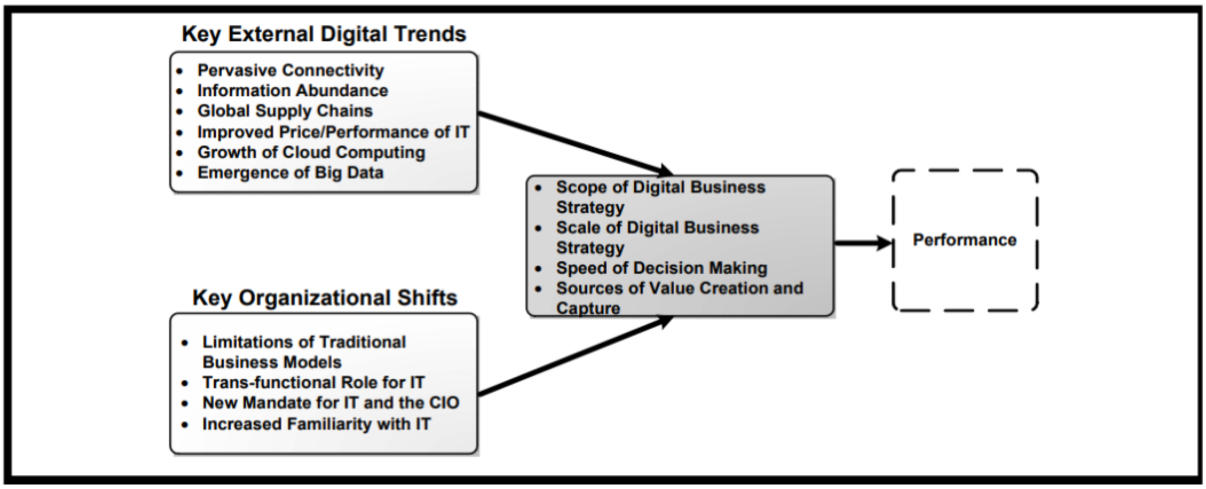

Figure 1: Drivers of the four key themes of digital business strategies

Source: Bharadwaj et al. (2013)

2.2 Scope of Digital Business Strategy

One of the fundamental questions in strategic management relates to corporate scope as shown in Figure 1 above, which defines the portfolio of products and businesses which retail sector is offering as well as activities that are carried out within a retail's direct control and ownership. Bharadwaj et al. (2013) pointed out that understanding the scope of digital business strategy helps to conceive its relationship to retail firms for SMEs, industries, IT infrastructures, and the external environment, and how digital business strategy can be more effective in a variety of settings. Conceptualizing competitive strategy under digital conditions raises the question of how business scope is impacted by digital technologies. Therefore, SMEs in the retail sector should develop their scope of digital business strategy by taking into consideration the digital conditions in which they are operating.

2.3 Digital Business Strategy Transcends Traditional Functional and Process Silos

Digital business strategy is different from traditional IT strategy in the sense that it is much more than a cross-functional strategy, as SMEs in retail sector have various functions such as production, marketing, sales, finance, human resources management, research and development and many other functions and it transcends these traditional functional areas and various IT-enabled business processes (such as order management, customer service, and others) (Bharadwaj et al., 2013). Therefore, digital business strategy can be viewed as being inherently trans functional. All these functional and process strategies are encompassed under the umbrella of digital business strategy with digital resources serving as the connective tissue. Digital business strategy relies on rich information exchanges through digital platforms inside and outside organizations that allow multifunctional strategies and processes to be tightly interconnected with the aid of interfirm IT capabilities (e.g., Rai et al.2012).

2.4 Digital Business Strategy Includes Digitization of Products and Services And The Information Around Them

The formulation of the digital business strategy includes the design of products and services and their interoperability with other complementary platforms, and their deployment as products and services by taking advantage of digital resources. Many are beginning to see the power of digital resources to create new IT capabilities and craft new strategies around new products and services (e.g., Rai et al. 2012; Ray et al. 2005; Sambamurthy et al. 2003). Therefore, firms in retail sectors should take this approach into consideration when formulating their digital business strategies to gain competitive advantages over their rivals.

2.5 Digital Business Strategy Extends the Scope Beyond Firm Boundaries and Supply Chains to Dynamic Ecosystems That Cross Traditional Industry Boundaries

In a digitally intensive world, firms operate in business ecosystems that are intricately intertwined such that digital business strategy cannot be conceived independently of the business ecosystem, alliances, partnerships, and competitors. Furthermore, the use of digital platforms enables firms to break traditional industry boundaries and to operate in new spaces and niches that were earlier only defined through those digital resources (e.g., D'Adherio 2001; Klein and Rai 2009; Rai et al. 2012; Saraf et al. 2007). It is against this background that, SMEs in the retail sector should extend their digital business strategies beyond the boundaries and supply chain to dynamic ecosystems that cross traditional boundaries if they are to survive in the digital era.

3. METHODOLOGY

A systematic literature review approach was used to establish and assess the current knowledge base that informed the development of a framework for digital business strategies for SMEs in the retail sector. A key factor of adequate searching was the identification of keywords using leading databases (Google Scholar and Science Direct). Overall, 115 articles had to be analysed to extract interesting insights.

3.1 Systematic Review Methodology

Figure 2 below demonstrates the process which was followed. The articles reviewed were current articles that ranged from 2018 to 2023. Google Scholar and Science Direct are the two basic and accessible platforms utilised to search for relevant journal sources which then were evaluated in relation to the study objectives. These articles were reviewed for relevance to the study by considering their titles, abstracts, and introductions. 80 articles were shortlisted from 115 articles in the preliminary research however, after carefully screening the articles and applying a set of criteria, 32 articles were finalized which formed the sample for this study. The presentation of the findings was guided by themes emanating from the two objectives that informed the study.

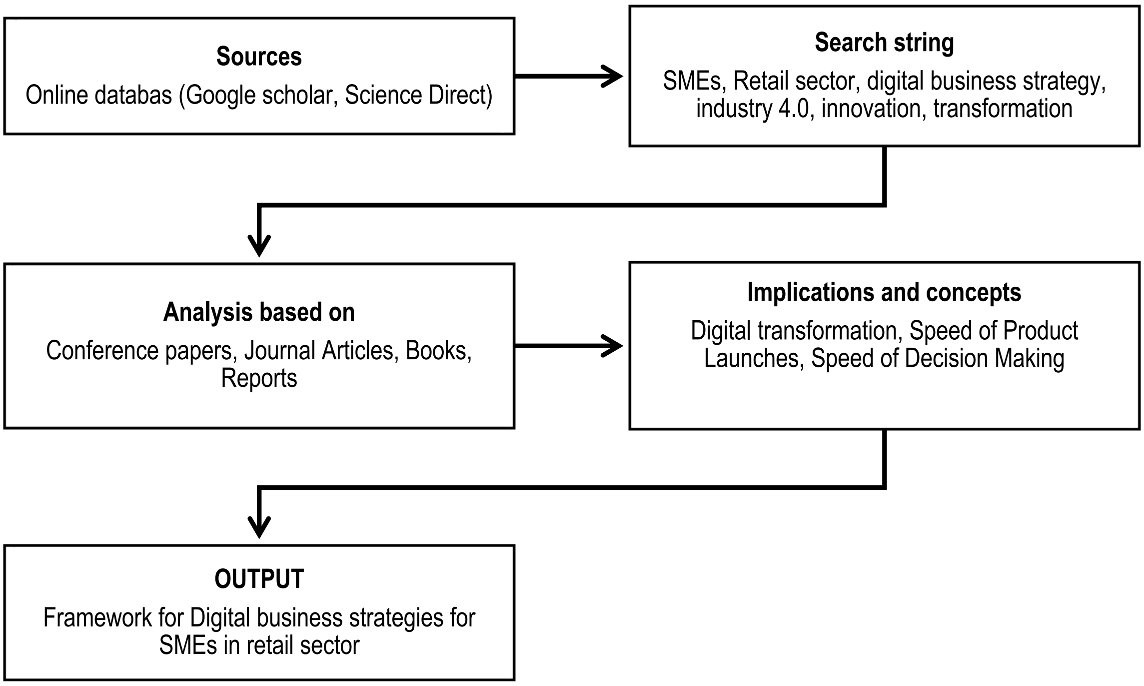

Figure 2: Systematic Literature review

4. RESULTS

Tärnell (2018) found out that successful DBSs includes improving the organisation's innovative ability and creating opportunities for new innovations. Tärnell (2018) emphases that this can be done by working more agile, introducing new competences and co-innovating with customers of the firm. Gül (2020) established that the DBS can have disruptive impact on incumbent firms' current business and create completely new products or services and that companies that have not been able to form or develop their digital business strategy will lose their competitive advantage among their competitors and lose their position in the sector.

A recent study by Roland Berger (2015) finds that industrial-age industries such as automotive, logistics, health, electronics, machinery, and energy are next to follow the path to digital transformation. Their transformation is driven by new opportunities for data collection and exploitation; the ubiquitous connectivity of products, infrastructure, companies, and customers; and the ever-expanding capability of components, products, and systems to make decisions autonomously. The same study also reveals that, on average, less than one-third of managers from these sectors believe their companies are well-prepared for the digital transformation. This finding is unsurprising, as business executives in these organizations must reconstruct their mindsets from regarding IT as a subordinate support function, to understanding digital technologies as an integral part of business innovation (Yoo et al., 2010). At the same time, their IT executives must learn to create and monetize value for customers (Bharadwaj, Sawy, Pavlou, & Venkatraman, 2013). SMEs in retail sector should therefore reconfigure, reorient, and reengineer their business processes, models, and strategies by riding on benefits of digital technologies in this dynamic environment.

Digital technologies also provide different forms of dynamic capability suitable for turbulent environments (Pavlou and El Sawy 2006, 2010). Digital technologies transform the structure of social relations in both consumer and business areas through social media and social networks (Susarla and Tan 2012). Bharadwaj et al. (2013) further indicated that scale of digital business strategy has been a primary driver of profitability in the industrial age. Scale confers benefits of lower unit cost of products and helps enhance profitability. When infrastructure becomes increasingly digital, rather than thinking of scale only in terms of physical factors of production, supply chains, or geographic coverage, SMEs in retail sector need to think of scale in both physical and digital terms.

Findings suggest that the degree to which firms digitize business processes does vary as a function of firm age and size (BarNira, J.M, & Augerc, 2003). BarNira et al. (2003) also found out that established firms digitize activities associated with marketing, administration, and communication more than newer firms and that larger firms digitize marketing activities more than smaller firms. Their results further suggest that the relationship between digitization and innovation efforts are stronger in newer firms than in established firms and that the relationship between digitization and low-cost efforts are stronger for smaller firms than for larger firms. This assertion therefore implies that SMEs in retail sector have a potential of growing from SMEs to large firms if they digitalise their business models and strategies in their various functions.

5. CONCLUSIONS AND RECOMMENDATIONS

Today, where competition among sectors is more intense and harder than ever, enterprises have started to implement innovations in their strategies. These new strategy moves are mainly on technology, informatics, and software. The companies have focused on their investments in social network advertising to keep themselves at the forefront and increase their profit rates.

To keep pace with digital transformation, information and communication technologies have been used in business processes and the concept of digital business strategy has emerged. It is seen that successful company implementations that adopt the understanding of digital business strategy which differs from traditional strategies in terms of certain criteria such as market entry, production, storage, distribution, workplace, organizational commitment, communication style and organizational structure, have shown great gains in the future.

SMEs in retails sector should consider the developments in digital technologies as opportunities, and use technologies appropriate to their own culture, goals, structures, and processes to go beyond customer expectations and develop new business models. Speed of Digital Business Strategy although time has been recognized as an important driver of competitive advantage for in the strategic management literature for quite some time, it takes on a more central role in digital business settings. Pervasive connectivity challenges companies to think about time (or more specifically, speed) in important ways (Holotiuk & Beimborn, 2017).

5.1 Speed of Product Launches

Digital business strategy should accelerate the speed of product launches by SMEs in retail sectors. Pure-play digital companies such as Facebook, Google, and Amazon appreciate the importance of developing and launching a timed series of products for SMEs in the retail sector that take advantage of improvements in computer hardware, software, and connectivity (Bharadwaj, Sawy, Pavlou, & Venkatraman, 2013). The speed of product launches set by these companies now compels companies that are in the hybrid (digital + physical) space to also accelerate their product introductions. Thus, when traditional retail firms add digital dimensions to their business strategy, the clock speed of product launches is recalibrated by the speed set by the pure-play companies. Under such conditions, managers across a variety of industries including SMEs in the retail sector find themselves with capabilities that are misaligned with those of their new competitors (Bharadwaj, Sawy, Pavlou, & Venkatraman, 2013).

5.2 Speed of Decision Making

There is a consensus that technology has allowed firms to speed up decisions that otherwise might be slowed due to information flows up and down the hierarchy through multiple layers of management (Bharadwaj, Sawy, Pavlou, & Venkatraman, 2013). Speed as a dimension becomes important in the context of responding to customer service requests in real-time through Twitter, Facebook, and other social media platforms. Slowness in response could mean customers moving away from companies perceived as being out of tune with the new reality. Therefore, SMEs in retail sector should speed up in their decisions by using real-time platforms of social media to maintain and increase their customer base.

5.3 Increased Value from Information

While information-based businesses have existed for a long time (e.g., newspapers and magazines) in physical forms, the digital business context brings new opportunities to create value from information. As magazines abandon their physical formats (e.g., Newsweek), they need to fundamentally rethink their unique source of value through curating content and assess the balance between subscription and advertising (Bharadwaj, Sawy, Pavlou, & Venkatraman, 2013). Google, Facebook, and eBay are just a few examples of new value created from information that goes beyond niche areas such as financial services whose business models rely on accurate, timely information. Moreover, many SMEs in the retail sector should be able to fine-tune their actions and personalize their offerings based on information about customer preferences through Facebook, Twitter, and others. In addition, many business models based in information have emerged in areas such as healthcare and energy.

The characteristics of digital business models are different from traditional ones, and this becomes apparent when looking at the example of the digital ecosystem. First, digital products and services can be reproduced for practically zero marginal cost and become exponentially more valuable as more users join (e.g., Facebook) (Shapiro and Varian, 1999). Second, while value is traditionally created within a firm and then sold to clients, in digital business models value is determined in use (Vargo and Lusch, 2008). For instance, smartphones per se are of little value until they are used as an interface to access services (e.g., telephony, navigation, mobile payment). Third, digital business models rely on digital platforms to balance benefits among an ecosystem with multiple organizations and individuals involved. The framework below emphasizes the importance of customer contact points (i.e., interface), the central role of digital platforms (i.e., service platforms) and the need to orchestrate a complex ecosystem of multiple actors (i.e., organizing model). Remane, et al. (2017) assemble digital business models into five components:

1. Value proposition: SMEs in the retail sector should see the reason why a particular customer is willing to pay for a product or service. Value creation logic describes the logic of creating and delivering value; an important view in this approach is the network's effectiveness and its approach to stakeholders.
2. Interface: SMEs in the retail sector should provide a platform that promotes interaction between the customer and the service platform, these could be the google play store.
3. Service platforms: SMEs in retail sector should provide engines to enable delivery of products or services. These engines should be user-friendly and should be offers such services for free it the objective is to increase it usage and uptake.
4. Organizing model: SMEs in retail sector should have structure and processes of the ecosystem to create the products and services.
5. Revenue model: The reason why SMEs in retail sector are in business is to generate revenue for a profit. SMEs in retail sector should distribute its revenues and cost among the ecosystem participants.

6. RECOMMENDATIONS

The following framework Figure 3 below which shows the digital business strategies for SMEs in retail sector is recommended which can help to increase SMEs retail performance in digital environment.

SMEs in retail sector should be able to discover digital business models and the related digital business strategies which are four iterative phases for innovating new digital business models: discovery, development, diffusion, and evaluation of impact (Fichman Dos Santos, Brian & Zheng, 2014). As shown in Figure 3 below. The successive phases might be supported better by other tools and methods (e.g. business model road mapping by de Reuver, Bouwman,and Haake).

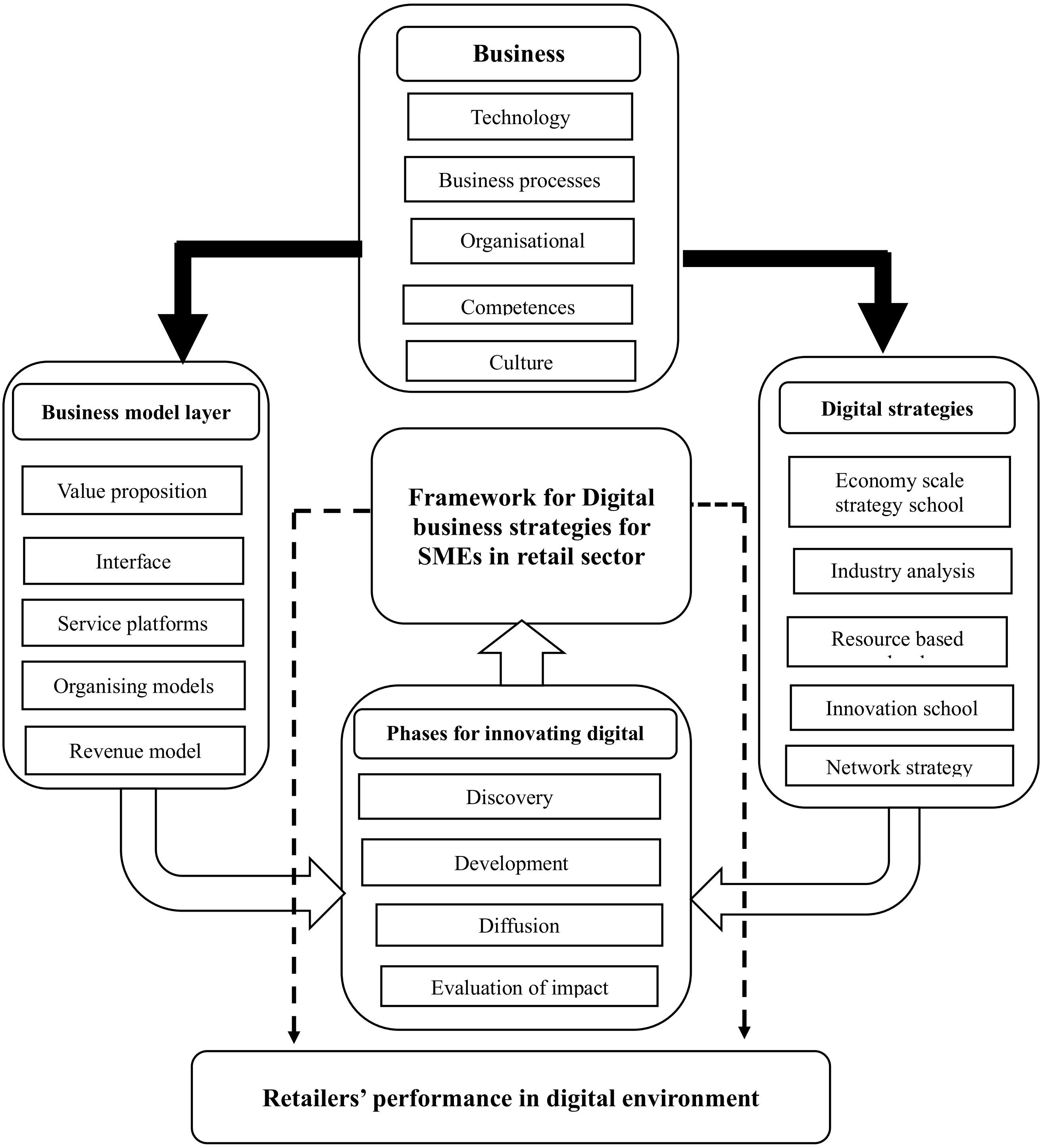

Figure 3:Framework for digital business strategies for SMEs in retail sector

Based on the business dimension for SMEs in retail sector as indicated in Figure 3 above. The following are the recommendation for SMEs in retail sector as shown in Table 1 below.

Dimension	Recommendations
Technology	SMEs in retail sector should introduce new digital technologies such cloud computing, Internet of Things, big data, and experimentation with new technologies. This can be done after designing proper business models based on the various functions of the firm. Various digital business strategies should be formulated which will feed into the framework by following various processes which will ultimately in a high level of business performance for SMEs in a digital environment.
Business Processes	SMEs in retail sector should formalise existing processes by reengineering of processes being Digitalized. SMEs in retail sector should also create processes for new functions (innovation).
Organizational Structure	SMEs in retail sector should create new roles brought by digitalized processes. They should also form new functions as required.
Competencies	For successful deployment of digital business model and digital business strategies, SMEs in retail sector should have introduction of core digital competencies, introduction of competencies linked to sales of smart products and services and reinforcement of competencies linked to project management.
Culture	Digital age come with some demands and requirements. SMEs in retail sector should introduce new cultural traits which allows some risk-taking and learning from errors.

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AN EVALUATION OF A VETERINARY MOBILE RECORD-KEEPING APPLICATION IN TERMS OF USEFULNESS AND ACCEPTANCE

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ABSTRACT
To ensure that veterinary students in South Africa demonstrate the necessary skills, knowledge, and experience, academic hospitals have implemented a mobile record-keeping application. This application provides a comprehensive overview of students' clinical exposure. In this qualitative case study, an opportunistic sample of volunteers participated in a group interview and an online questionnaire to evaluate the usefulness and acceptance of the application. The collected data were analysed based on variables from the Technology Acceptance Model (TAM), such as ease of use and usefulness. The results revealed that while participants found the booking system easy to use, there were shortcomings in terms of logging of procedures, the assessment, and meeting user expectations. These factors have a direct impact on the app's usage. Participants provided suggestions that, if implemented, could potentially enhance the utilisation of the mobile record-keeping app. This study confirms the importance of user buy-in and perceived usefulness when implementing educational software.

Keywords: mobile app; perceived ease of use; perceived usefulness; record-keeping app; technology acceptance model; veterinary education

1. INTRODUCTION

Since the adoption of technology has grown exponentially (Arkorful & Abaidoo, 2015), technology is of no use for education if it is developed and deployed, but not utilised by the students for learning (Jimenez, García, Violante, Marcolin & Vezzetti, 2021). In this study the technology under evaluation is a record-keeping mobile application (mobile app), intended to be used by clinicians and final year veterinary students at an academic veterinary hospital.

As part of preparing veterinarian students to function as practitioners from the first day that they leave the university (Wharton, Goodwin & Cameron, 2014), students spend approximately 18 months practicing and developing their skills in an academic hospital. During the training period of 32 clinical rotations, clinicians need to know the range of exposure the students have had to have a full picture of the students' experience and take remedial action if necessary. For example, students must keep accurate records and log all the cases that they see or treat.

In the past, students kept a paper-based record of their cases in the form of a logbook, signed by the clinician during their rotations. This paper-based logbook was first replaced with a web-based logbook and thereafter, a mobile record-keeping app developed by the director of the academic hospital and a software development company, that can be accessed from any of the hospital's smart devices. To have an app where students can record their experience as well as where clinicians can observe what they were exposed to, from any location, at any time, holds a lot of value for students (track their progress), clinicians (know student exposure) and tertiary institutions (learning analytics and to know where to fill in educational gaps) (Odendaal, Ntshabele & Rose, 2015).

The purpose of the mobile record-keeping app is to measure the quality and volume of training in an experiential learning environment. To use the mobile record-keeping app, students must create an account and login with a username and a password. The first screen that they would see is the Dashboard (Figure 1) where they can log a procedure, request an assessment, select procedures, and do assessments. Except from the four options mentioned on the dashboard, students can also access and book their rotations (Vetbox, n.d.).

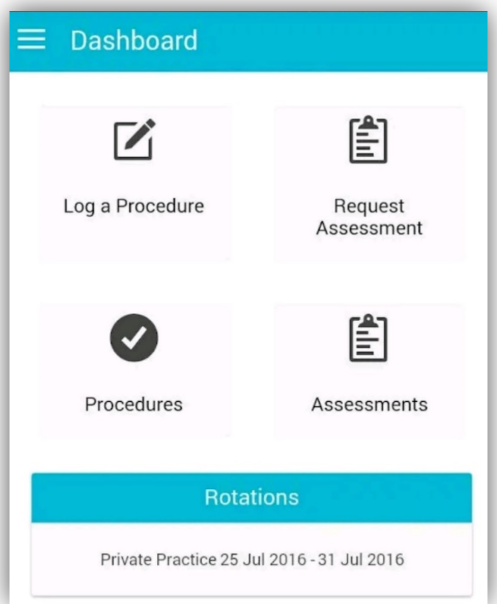

Figure 1. Vetbox mobile application dashboard

When using the mobile record-keeping app, students can log the procedures that they were exposed to as well as select the skills they performed. The evidence can be in the form of attached files and images and once a a procedure is logged, the clinician is notified immediately, and they can approve or reject the activity. Through logging and saving all the skills, students compile a portfolio of approved procedures and keep track of the history of their skills (Vetbox, n.d.).

Even though clinicians and students both confirmed the mobile record-keeping app was easy to use, the commitment to use the app was not as high as it should have been, and there was some resistance to using it. Therefore, in this study, we evaluated the use of a mobile record-keeping app by clinicians and students with regards to the usefulness and acceptance of the mentioned app. Like Ooi and Tan (2016), this study found that it is important to understand the aspects that influence the acceptance and use of the mobile record-keeping app. These aspects could influence the future revisions of the app. To answer the research question 'How do veterinary clinicians and final year veterinary students experience a mobile record-keeping app in terms of usefulness and ease of use?' the variables of the Technology Acceptance Model (TAM) were used to guide the current study (Davis, 1989). We do acknowledge that other factors might also play a role in combination with the TAM variables (Turner, Kitchenham, Brereton, Charters, & Budgen, 2010).

2. LITERATURE

2.1 Mobile devices and mobile apps

When using mobile devices in a mobile learning environment, the following principles are important. For example, mobile app designers must be reminded that mobile learning takes place outside of the formal learning spaces (Sølvberg & Rismark, 2012), the use of mobile devices is found everywhere (Sharples, Taylor & Vavoula, 2005), and the learning environments are often social constructivist (So, Kim & Looi, 2008). Mobile apps and mobile devices in higher education are reported as the tool of choice for mobile learning (Alioon & Delialioglu, 2015). The portability, size, and flexibility of learning at anytime and anywhere makes the use of mobile devices attractive to students (Shorfuzzaman & Alhussein, 2016; Sophonhiranrak, 2021). Mobile devices allow students to capture information, submit files, take pictures and videos, and communicate with other users, when the need arises (Muca, Cavallini, Odore, Baratta, Bergero & Valle, 2022). The abovementioned capabilities make a mobile device fit for purpose as a record-keeping device as seen in a variety of study fields, such as healthcare (Ventola, 2014), retail (Kimutai, Ngenzi & Kiprop, 2019), and agriculture (Guan, Shikanai, Minami, Nakamura, Ueno & Setouchi, 2006).

The use of mobile apps in veterinary practices was also investigated and it was found that practicing veterinarians believe that using mobile apps allows them to practice more effectively. Since mobile apps are used for accessing medical literature, treatment protocols, and clinical data, veterinarians also use it to view records, schedule appointments, and monitor possible crises (Andrews, Bulloch, Dennison, Elder, Mitchell, Rivenbank, Schiling, & Gallicchio, 2015). Therefore, it becomes imperative that students are exposed to using mobile apps during their studies.

For example, preclinical veterinary students use a mobile app to learn more about the real-world veterinary experience (Royal Veterinary College, 2021), while interns are requested to download an app to log the dates and hours of their internship practical experience or when they are shadowing veterinarians (Cornell University, 2017). These two examples indicate the growing value of keeping records with mobile devices and mobile apps in the field of veterinary science.

2.2 Value of record-keeping for veterinary students

The core competency of veterinarians is the ability to diagnose diseases and treat sick and injured animals to protect their health (South African Veterinary Council, 2016). To equip veterinary students with the necessary skills, attitudes, and knowledge during their university training (World Organisation for Animal Health, 2012), universities combine theory and practice in an authentic clinical setting by providing a wide range of hands-on clinical training to their students (University of California Davis, 2022; University Utrecht, n.d.). This type of clinical exposure offers students an opportunity to develop a wide range of skills and more importantly, to record or show evidence of these skills and exposure to clinical cases. It is essential for students to practice record-keeping and thereby keep track of their skills and practical experience (South African Veterinary Council, 2022).

When keeping records, students record patient information and provide evidence to the clinicians of the kind of hands-on practical experience they had during their clinical training. These records are of use to both students and clinicians, where the clinicians may potentially identify gaps in the training of the students while students develop the essential habit of record-keeping (Odendaal et al., 2015). Proper record-keeping allows for clinicians and universities to create the best learning environment for the students (Maxim & Five, 1997).

2.3 Student input

Students see themselves as active participants in the educational process, shaping their own educational experiences (Bowen, Burton, Cooper, Cruz, McFadden, Reich & Wargo, 2011). Keiller and Inglis-Jassiem (2015) state that academics should consider the opinions and capabilities of students when using innovations and technology in teaching and learning. Philips (2015) argues that including students' voices in decision-making processes about applications and their learning increases student achievement, adds leadership value as well as a different perspective other than academics.

When educational apps are developed, the purpose is typically to improve students' learning through making it useful (Strydom & Loots, 2020), provide meaningful goals (Brunstein, Schultheiss & Maier, 1999), and motivate students (Wu, Cheng & Bettney, 2014). However, educational software is often not used by students because it is developed from an educator's viewpoint, with limited input from students (user). Because of this disconnect between the developer and the user, the perceptions of students when using educational software varied from positive and valuable (Hoang, Johnson & McAlinden, 2022) to negative and rigid, where the lack of flexibility of the software and the lack of feedback are given as some of the reasons why educational software are not used (Kuiper & De Pater-Sneep, 2014). Therefore, like this study, the input of student users was needed to ensure that students benefit from educational software (Strydom & Loots, 2020).

2.4 Technology Acceptance Model (TAM)

Various diffusion and adoption theories and models have been proposed to study technology adoption from a user's perspective (Straub, 2009). Since the focus of this article is to delve into the perspectives of veterinary clinicians and their students, regarding the usefulness and acceptance of the mobile record-keeping app, it is crucial to create a sense of practical value to shift students' attitudes towards using the mobile record-keeping app on a regular basis (Martins, Quintana & Quintana, 2021). Therefore, the TAM (Davis, 1989) was selected.

Davis (1989) adapted Fishbein and Azjen's Theory of Reasoned Action (Legris, Ingham & Collerette, 2003), where users' commitment to use a particular technology is based on two critical elements: perceived usefulness and perceived ease of use. As a result, researchers often use the TAM when attempting to describe why users accept and use new technology (Venkatesh & Davis, 2000). This technology refers to Information and Communication Technology (ICT) and includes mobile devices (Jan, De Jager, Ameziane, & Sultan, 2019), mobile games (Chen, Rong, Ma, Qu, & Xiong, 2017), and mobile applications (Mohamed, Tawfik, Al-Jumeily, & Norton, 2011).

In Figure 2, the relationships between the different elements of the TAM illustrate how a system's ease of use and usefulness can directly affect an individual's perception and attitude towards using it. As a result, the users attitude influences whether they, as users, will change their behaviour enough to use the system regularly (Davis, Bagozzi & Warshaw, 1989). According to Davis (1989), perceived usefulness and ease of use are crucial user acceptance factors. As used in this study, perceived usefulness refers to the degree to which veterinary students and clinicians would find the mobile record-keeping app valuable and useful. Perceived ease of use refers to the effort required to use and master the mobile record-keeping app (Davis, 1989; Saadé & Bahli, 2005).

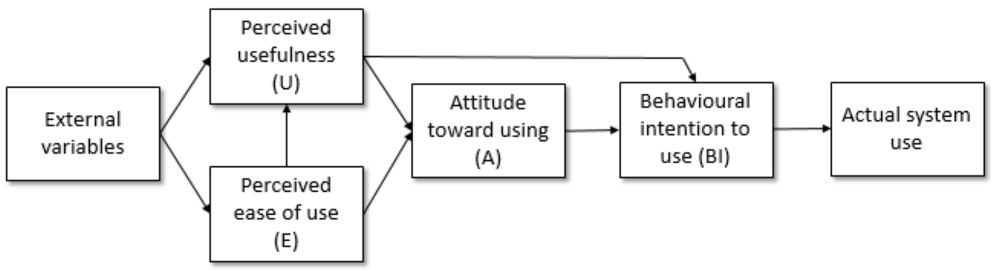

Figure 4. Technology Acceptance Model (Davis et al., 1989)

Although both perceived usefulness and ease of use play a role in user acceptance, usefulness relates more to user behaviour, than ease of use (Eksail & Afari, 2020). This may explain why although some of the veterinary students found the mobile record-keeping app easy to use, the uptake by others had not improved significantly. Understanding this reluctance to use the mobile record-keeping app is important to know, since developing an app that is easy to use, yet at the same time not seen as valuable, seems to be a pointless exercise.

Furthermore, it should be stated that the perceived usefulness and ease of use of a system are subjective to the person using it (Davis, 1989; Law, Roto, Hassenzahl, Vermeeren & Kort, 2009), where the user, the context, and the app or technology forms a tri-unit. Because user experience is dynamic, app developers must continuously consider user feedback and input (Keiller & Inglis-Jassiem, 2015; Law et al., 2009), especially throughout the development phases when designing, implementing, and improving systems or products (Wynn & Maier, 2022).

In this study, external variables might not have an influence on the technology acceptance of the participants, since all the students and clinicians have the same level of training and experience in how to use the mobile record-keeping app (Burton-Jones & Hubona, 2006). Although both the perceptions of students and clinicians are explored in terms of the beliefs of TAM (Davis, 1989), more focus will be placed on the perceived usefulness, since students and clinicians had already indicated that the mobile record-keeping app is easy to use. In this case, perceived usefulness will go together with the importance of keeping records of the cases or patients that the students consult on. Since these recorded cases are important for the student (keep records), it is also important for the clinicians (quality, assessment, and overall picture of exposure to cases) (Odendaal et al., 2015).

3. METHODOLOGY

3.1 Research design

To explore how veterinary clinicians and final year veterinary students experience a mobile record-keeping app in terms of usefulness and ease of use, a qualitative case study was conducted. Qualitative case studies are usually conducted to explore the experience of participants in the real-life environment, in this case both the clinicians and students (Creswell, 2007), while using the mobile record-keeping app when working in the academic hospital. These students are studying a bachelor's degree in veterinary science (BVSc) at a South African university. To conduct the study, ethical permission was received from the Faculty of Education and the Faculty of Veterinary Science.

3.2 Sampling method

The target population for the study were 5th and 6th year BVSc students in their final 18 months of study, and the clinicians who supervised them during their training. Both clinicians and students were under pressure to finish the academic year on time, and therefore, only a small group of students (5) and clinicians (3) were available and willing to participate. The study therefore adopted an opportunistic sampling approach (McLeod, 2014), which may limit the generalisability of the findings. Although this type of sampling may pose criticism as to the possible bias of participants, the current study focused on the usefulness of the record-keeping app as first-time users of the mobile record-keeping app, as a follow-up to a study on the use of a web-based record-keeping application. Even though the group of participants was small, all the participants using the record-keeping app and could potentially provide valuable insights into the participants' perspectives of using the application. The three clinicians, two males and one female, are experts in the field of reproduction, small animal medicine, and dermatology and pulmonology respectively. Two male students and three female students participated in the study.

3.3 Data collection instruments and analysis

The researchers employed a combination of a semi-structured group interview and an online questionnaire, allowing for a comprehensive understanding of the participants' viewpoints. Group interviews were selected instead of individual interviews since the researchers wanted to observe how the students and clinicians would react to each other's responses. This choice was made to gain insight into their varying perspectives, thereby assessing the usefulness and ease of use from multiple angles.

Semi-structured interviews allow the researcher to add probing questions if necessary and for participants to answer as they saw fit (Harrel & Bradley, 2009). Five students and three clinicians attended the hour-long group interview, while four students and one clinician responded to the online questionnaire.

Having consented to their responses being used for the purpose of this research, participants were asked to describe their experiences using the mobile record-keeping app in terms of ease of use, usefulness during booking, logging, and assessments. The recording of the group interview was transcribed, and the text analysed according to phases described by Braun and Clarke (2006). Deductive coding, using the attributes of TAM (Davis, 1989), was used to analyse the data for themes and categories that relate to the usefulness, ease of use, and future suggestions for improvement. In each theme, the focus was on the three distinct record-keeping purposes that the app was developed for, namely the booking of rotations and the logging and the assessment of procedures. An ongoing review and analysis were conducted to refine the themes and ultimately develop a comprehensive narrative for each theme (Braun & Clarke, 2006). The pseudonyms CGX and SGX are used for the clinician group interview and the student group interview respectively.

The invitation to participate was open to all students, thus the researchers were unsure of the number of attendees. Consequently, a group interview was conducted to gather the contact details of the participants. After the group interview, participants were invited to complete an online questionnaire. Except for the biographical detail, the questions were pertaining to ease of use (training, login procedure, access, and capabilities of the mobile record-keeping app), usefulness (recording of procedures, assessment), motivation (progress bar and feedback), and behavioural intent (what will encourage a student to use the app, suggestions for improvement). The feedback to these questions provides additional information ensuring that information on all the aspects of the mobile app was given. A Likert scale response was used for the close-ended questions. Some questions were followed up with open-ended questions and the questionnaire ended with four open-ended questions. The open-ended questions were analysed as described by Braun and Clark (2006) earlier in the section. The pseudonyms CSX and SSX are used for the participants of the student questionnaire.

4. RESULTS AND DISCUSSION

The results of the study are discussed through first assessing the ease of use and usefulness of the mobile record-keeping app (mobile app). Following the ease of use and usefulness, aspects that motivate students to continue using the mobile app and possible indications of behavioural intent to use the mobile app, will be described. Lastly, recommendations for improving the mobile app will be discussed.

4.1 Ease of use and usefulness of mobile app

The study found that the **booking** system was well received by both clinicians and students. They found that *"booking assessments has definitely been made easier"* [SG4], and the clinicians were impressed with the system's functionality which enabled students to make their own rotation bookings

[CG2]. This suggests that the online booking system was successful in meeting the needs of users and was well-designed to be user-friendly and efficient.

One way to practice the skill of record-keeping is to allow students to log all the cases and procedures they are observing or assisting on, on the mobile app. In contrast to the older web application, participants found the logging functionality of the mobile app both useful and easy to use. While it is time-consuming to log a procedure [SS4], students do see the value of these records and log most of their procedures either at the end of the day [SS1] or at the end of the rotation [SS2, SS3].

Based on the participants feedback, it appears that the mobile app has not delivered the expected practical outcomes, even though its usefulness was established theoretically. The students wanted more guidance and clear indications on the number of procedures they were required to perform and the level of success they needed to achieve to be considered competent. Students expected the app to provide this information before they started logging procedures, stating that such an aspect would be useful to them. This highlights the importance of considering practical outcomes and user feedback in the design and development of mobile applications (Brunstein et al., 1999; Martins et al., 2021). According to [SG1]:

> *"Even if you are in outpatients or in surgery, you only have a certain set of skills that you must get done. Then at the end you achieved, you pass the surgery, then you are done — it only gets accepted once or twice not 500 times."*

The clinician participants found the assessment functionality of the mobile app easy to use, however, they did not find it to be particularly useful or effective. They rated this functionality as the least convenient of all the features of the mobile app. For example, the 'Approve all' feature of the assessment was considered educationally flawed by clinicians and they did not agree with using the option [CG2]. This suggests that the assessment functionality of the mobile app may need to be improved or revised to better meet the needs and preferences of the clinicians.

Selecting the 'Approve all' option in the mobile app could lead to carelessness on the part of the clinicians, who might select it without carefully considering the actions of the students under their supervision. This could compromise the quality of the students' learning, which would defeat the purpose of the app, which is to improve learning. This is a valid concern, and it highlights the importance of ensuring that the app's design and functionality supports accurate and thorough evaluations of student performance. It also suggests that the app should be designed to support a process of evaluation that is consistent with the principles of good practice in student assessment, as proposed by Strydom and Loots (2020).

Both the participant students and clinicians experienced the booking of clinical rotations and to a limited extent, the logging of the procedures, useful and easy to use. Like the work of Martins et al. (2021), the app has not fulfilled students' expectations in terms of setting measurable goals, resulting in the perception that the current version of the logging functionality is personally, not useful for them. Further, clinicians did not experience the assessment functionality of the mobile app useful and rather experienced it as flawed.

3.4 Motivational aspects of mobile app

The participant clinicians found the 'first come, first serve' method of heterogeneous student grouping to be positive. This randomised booking allocation resulted in a fresh mix of students in each new clinic. Both the clinicians and students reported eagerness and willingness to continue using the mobile app for online bookings. While a student participant commented:

> *"I went to out-patients with this existing group, and I didn't know anybody from bar of soap, and I enjoyed working with every single one of them"* [SG2]. A clinician participant mentioned:

> *"So, a lot of students that used to be a little bit protected and shy, they now are actually participating in the group."* [CG2]

Individuals' motivation and well-being are strongly influenced by the pursuit of personally meaningful goals (Brunstein et al., 1999). Students seemed motivated to **log** procedures through the mobile app, since they had a concrete measure of their progress. The participants reported that the mobile app was perceived as a useful tool for tracking the progress of students towards becoming competent veterinarians and they agree that the progress bar motivates them to log more cases, however, the progress *"did not reflect their effort"* [SS4].

The participants indicated that, despite the number of skills they must log, they would still like to be able to log procedures that are not on the list, those that are related to rare cases or that are highly specialised, for their own reflection. As [SG2] indicated, *"it would be nice if we could log weekends …."*. This is an indication of their intention to use the mobile app and mention how seeing their own progress on the progress bar, motivates them [SG6].

Although students do not fully understand the value of keeping records of their patients, the compulsory nature of the logs has become an external motivator for students to use the app to log their procedures. The usefulness of the system was now externally situated, as shown by the following comment: *"The reason why we log is because we don't want to be excluded for the exams."* [SG1]

To not be excluded from exams, students start logging procedures they had merely observed. This behaviour may indicate that the students were focusing more on meeting the benchmark, rather than gaining meaningful experience or feedback. Describing the problem, [SG2] commented:

> *"To make up their percentage to get exam entrance they, as with the semen collection, they just log in that they saw 10 ram semen collection and I don't think it is fair on other persons behalf."* [SG2]

The influence of assessment scores on motivation (Wu et al., 2014) is demonstrated in the feedback of the participants. Both the students and clinicians suggested that adding a mark would provide useful feedback on student performance and would motivate clinicians to pay closer attention to student progress.

Although participants acknowledged the random booking system and progress bar as a motivating factor to use the mobile app, the logistical issues seem to have hindered the full utilisation of the logging and assessment functionality of the app.

3.5 Indications of behavioural intent to use the mobile app.

The clinicians already found the **booking** system to be valuable and were excited about the prospect of being able to view a comprehensive list of each student's practical exposure during their clinical year. This information is important for ensuring that students are prepared for the workforce after graduation, highlighting the importance of using the mobile app (South African Veterinary Council, 2022).

The participants suggested that if the list of procedures were grouped by clinic or rotation, it would motivate students to actively log the procedures relevant to that rotation, increasing their intent to use the mobile app. Clinicians also found it more efficient to have the generic procedures separated from the clinic-specific procedures, as it would improve the teaching of skills during the rotation and assessment of student mastery.

Clinicians also suggested that they would benefit from a shorter list of clinic-specific procedures to assess, as it would allow them to organise verification and assessment opportunities during or at the end of the rotation. This would allow for more focus on the quality of the assessment and clinic-specific feedback could be discussed with students. The student and clinician participants suggested that, in order not to compromise the quality of assessments, the generic skills could be verified and assessed by the qualified nursing staff or dedicated clinicians in the skills laboratory [SS3, CG1].

Some of the clinicians raised concerns that certain procedures only required them to verify their assessment with a ‘Yes’ or ‘No’ response. They felt that without the addition of constructive feedback, the response did not contribute to a student’s learning, therefore, discouraging them from using the assessment function. Student participants also felt strongly about feedback and confirmed that they would like to receive comments such as, *“you do a good job”* [SG3] instead of a clinician just accepting the submission of their skills.

This aligns with previous research on the importance of feedback in professional development (Kuiper & De Pater-Sneep, 2014). Students also indicated that they would use the mobile app if the clinicians approved all the skills / procedures that they log as well as provide regular feedback (Wu et al., 2014). This statement by the students could be interpreted as a willingness to use the mobile app if improvements are made.

3.6 Recommendations for improvement for using a mobile app

Despite the positive feedback, there remain areas for improvement. Clinical staff reported that booking rotation slots was not well managed in each clinic. For instance, some clinics allowed six to eight students to participate in a particular rotation, however, only four students signed up, causing practical difficulties for the clinic [CG2]. On the other hand, some clinics were overbooked with as many as 17 students signing up for a particular rotation, which resulted in reduced practical learning opportunities. An undersubscribed clinic could also result in poor healthcare with negative results. Consequently, the clinicians recommend that the system establish a well-researched minimum and a maximum number of students per clinic for the purpose of creating an optimal learning environment, which would also enable quality assurance regarding patient care.

Both clinician and student participants further suggested that they would benefit from a feature that would hide the option to submit a procedure for verification once the maximum number of required procedures is reached. This would allow students to continue logging a particular skill for their own records, without requiring any further action from the supervisory clinician. In doing so, the repetitive logging of the same procedures will be prevented. A contributing factor to the frustration of the students, was that after they logged a procedure, they could not increase the quantity but must log the procedure repeatedly. Their frustration is evident in the following comment:

> *"Make it possible to select several times a procedure's done. E.g., Instead of logging 50 cows bled, one should be able to select a number (50)."* [SS1]

> The clinicians also expressed that the mobile app *"assessment should probably only be on the critical [procedures], because if you can't do those you shouldn't be a vet."* [CG1]

The assessment experience could be improved by providing constructive feedback to students after they log their skills. Clinicians who participated in the study reported that feedback from a qualified mentor could assist students who are struggling, by giving them insight into their own levels of competence and progress. One clinician participant suggested that the logging of skills need to contribute to a revision session where the students discuss their procedures done over a period [CG1].

In conclusion, this qualitative case study provides valuable insights into the acceptance and usefulness of a mobile record-keeping application among veterinary students (Maxim & Five, 1997). The findings highlight the importance of considering user expectations and refining the application's features to enhance its usability and effectiveness (Hoang et al., 2022). This study serves as a useful foundation for future research and development in the field of educational software for veterinary education.

5. CONCLUSION

Mobile devices and apps have infiltrated education including veterinary training and practices (Andrews et al., 2015). Not only is it a convenient device to use, it allows students to retrieve information and record information, such as patient cases. For veterinary students, record-keeping is a crucial skill they must have when starting their career life (South African Veterinary Council, 2022); and using a mobile app, could be a convenient tool to accomplish it.

The study confirmed that while the mobile app was user-friendly, the lack of perceived usefulness had a negative impact on students' attitudes, their intention to use the app and actual usage of the system. The study suggests that addressing the issues of perceived usefulness and providing feedback on the logged skills may help to increase the adoption and long-term usage of the app by students. It seemed as if both the clinicians and the students did not fully grasp the value of the app, except for the online booking system, however, both the logging of skills and the assessment systems were not perceived as useful. The findings agree with those of Eksail and Afari (2020), who found that only when technology users recognise the usefulness of a specific technology, they might have a positive attitude towards using the technology.

The study's findings align with the theory of Davis (1989), that individuals are more likely to use an app if they find it useful, even if it is not easy to use. The study also suggests that subjectivity and context (Law et al., 2009) may have an impact on students' perceived usefulness and ease of use of the mobile app which highlights the importance of involving the students from the beginning to book, log, and be assessed. The study reinforces the notion of user buy-in and perceived usefulness when implementing educational software. It underscores the significance of providing an intuitive and functional interface and ensuring that the application aligns with the users' requirements and offers features that enhance their learning experiences. Without the buy-in from the students and clinicians, be it directly or indirectly, the realisation of the usefulness of the application would likely never be acknowledged. Suggestions have been made for improving the mobile app to increase its perceived usefulness for students and clinicians for booking, logging, and assessment purposes. These suggestions aim to address the issues that were identified in the study and make the app more valuable to its users.

The current study also found that the drive to use the application largely depends on external motivation, such as completion of clinics and access to the final examination. Although the use of the mobile app could ensure efficiency for the clinicians (number of students in rotations, less procedures to assess, more time for discussion feedback), it might not necessarily enhance learning for the students. Although, it might seem that student and clinician participants are using the mobile app, it might not necessarily come from the app itself, but rather from external factors that create a sense of usefulness.

As demonstrated by TAM (Davis, 1989), the perceived usefulness (internally or externally motivated) might increase the use of the mobile app during students’ final year of studies provided that they understand the importance of what this app is doing as well as the improvements made to the mobile app. Due to the small number of participants, the results are not generalisable and could only be interpreted as aspects to take into consideration when designing and revising mobile apps, such as a record-keeping mobile app. Therefore, to inform theory, it is recommended that more research be done with larger scale studies, where the acceptance of the mobile record-keeping app is investigated among diverse student populations, where validated instruments could be used.

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MOBILE LEARNING IN THE TECHNICAL AND VOCATIONAL EDUCATION AND TRAINING SECTOR: A PEDAGOGICAL PLUS

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ABSTRACT

Accessing education and training in South Africa is a current topical issue. Themes such as poor access to education and training, the relevance of the applied training methods, training distractions, lack of expertise, *inter alia*, dominate the debates on this polemic issue. Most topical are the limitations of the Eurocentric pedagogy which seems not to be applicable during the times of uncertainties. However, mobile learning seems to have become a panacea in the South African Technical and Vocational, Education and Training (TVET) colleges during the times of uncertainties. In mobile learning (mLearning) are ensconced, benefits which enhance education and training as found by a study which informs this paper. This paper explores how a TVET college in the Eastern Cape Province of South Africa benefited from mLearning as a pedagogy. Applying a qualitative research design and using questionnaires and interviews to gather data from the purposively sampled students and staff, the study found that mLearning increased learner engagement in education and training, promoted accessibility to education and training, was cost-effective, improved training efficiency, motivated the learners to continuously engage in education and training activities, and there was a high retention of learners in education and training. These findings underline the importance of shifting from traditional approaches to education and training and pursuing perspectives that view mLearning as a pedagogy of choice in an era characterised by the Fourth Industrial Revolution, Artificial Intelligence, frequent natural disasters, and civil unrests.

Keywords: Eurocentric pedagogy; learner performance; mLearning; pedagogy; raining opportunities; TVET colleges

1. INTRODUCTION

The provision of education and training during the times of uncertainties and the backdrop of the Fourth Industrial Revolution (4IR) is currently a site of intense conversation. A plethora of recurrent themes such as poor access to education and training, relevance of training methods, training distractions, lack of the education and training material, lack of expertise, *inter alia*, are embodied in such debates. These debates illuminate how the 4IR enhances education and training processes, and how the times of uncertainties disrupt education and training processes. Education and training processes have not been insulated from the impact of the times of uncertainties such as pandemics, natural disasters, economic depressions, civil unrests, load shedding, political conflicts, etc. The monopolized Eurocentric pedagogy (European education model characterised by curriculum-teacher-learner-class-supervisor approach and heavily relies on the use of textbooks in the classroom (Arday, Belluigi & Thomas, 2020)) mostly applied in the South African Educational and Training (TVET) colleges, seems not applicable during such challenging times. A case in point is during the Covid-19 pandemic era, when acessing education and training turned out to be a nightmare for many learners. In many educational institutions, despite pockets of remote learning opportunities, including broadcast education via television and radio (World Bank Group, 2020), the physical shutdown of institutions halted the majority of students' education and training (Thomas, 2020). For many learners, their education only resumed when they were able to return to face-to-face classes because the mostly depended-upon Eurocentric pedagogy was inapplicable during the pandemic. However, mobile learning seems to be a panacea in those difficult times as found by the study (Madambi, 2023) which informs this article. Enhanced by the 4IR and Artificial Intelligence (AI), mobile learning has not only become an alternative or complementary pedagogical strategy in facilitating education and training, but a plus to the sector. Literature shows that mobile technology has opened a world of opportunities for education (Keegan, 2005; Traxler, 2009). In mobile learning are nestled benefits that enhance education and training. Of particular interest, for the purpose of this paper, are the benefits of mobile learning in education and training at the cusps of the 4IR and times of uncertainties. According to Madambi (2023), some colleges were pursuing approaches which promote the creation of educational content for use on mobile devices, ensuring gender equality in the distribution of the gadgets and improving connectivity options. The colleges were also promoting the use of mobile technology to improve communication and education management, raising awareness of mobile learning through advocacy, leadership, and dialogue. This is in line with the United Nations Educational, Scientific and Cultural Organisation (UNESCO) guidelines on mobile learning which promotes among other things; accessibility, equity, safety, and advocacy in the application of mobile learning (United Nations Educational, Scientific and Cultural Organisation, 2013).

Although mobile learning is relatively new in South Africa, there is a moderate body of literature covering its implementation, the benefits, and related challenges. This paper illuminates the benefits of mobile learning in the TVET College's education and training processes at the backdrop of the 4IR and the times of uncertainties. *Ipso facto* the illuminated benefits, the article will argue for the adoption and full-time implementation of mobile learning in the TVET sector, guided by the UNESCO (2013) mobile learning guidelines among other factors, challenging the hegemony of the Eurocentric training approaches in the process. It is against the backdrop of the benefits and the pursued argument that the paper attempts to provide a pathway for the seamless integration of mobile learning into the existing TVET colleges' educational practices. The article will first give a cursory glance on mobile learning, then briefly give an overview of the adoption and implementation of mobile learning in South Africa and beyond, and then describe the framework that guided this study to put the article's argument into context.

2. MOBILE LEARNING: A CURSORY GLANCE

Mobile learning is becoming a key component in the pedagogical transformation of the education and training methodologies in South Africa. The challenges posed by the times of uncertainties, the limitations of the Eurocentric pedagogy in the existing world, the need to keep pace with the 4IR and also meet the needs buttressed by 4IR, and then considering the lack of access to devices such as desktops for online and eLearning, and the low cost and ease of access to mobile phones makes mobile learning not only an alternative pedagogy, but a pedagogy of preference. The modern-day TVET pedagogy is not fully transfigured without mobile learning because mLearning is integral to education and training such that we cannot isolate it from which it is a part. This makes mobile learning a matter of curriculum design, planning, development, and that of education and training processes.

Mobile learning is a way of accessing learning content through mobile devices such as phones and tablets. It involves the use of mobile technology, either alone or in combination with other information and communication technologies to enable learning anywhere, anytime (Kraut, 2013). The method allows learning at the point of need, enabling users to access content whenever and wherever it suits them (West & Vosloo, 2013. The most important element of mobile learning is its focus on the mobility of the learner - giving them the ability to choose when and where they want to learn at their own pace, increasing engagement and improving knowledge retention (Bikanga, 2018). Mobile learning has three main characteristic features which defines it. It is used to deliver micro learning content designed to maintain learners' attention and bolster attention retention (West & Vosloo, 2013). The content is carried in form of social media feeds, videos, animation, games, quizzes, among other exciting activities. Mobile learning is also characterised by social learning; where it is utilised to replicate online behaviour to boost engagement through chatting, connecting with peers and sharing insights (Iqbal & Bhatti, 2020). The other characteristic feature of mobile learning is seamless access, since it is accessible anywhere and anytime (Kraut, 2013).

Several governments and organisations are transforming their education and training curricula in response to the demands of 4IR and the recurrence of the times of uncertainties (UNESCO, 2016). This has seen a rise in the use of online learning (where students and instructors interaction are frequent), eLearning (where learning is more self-paced, with less student-facilitator interaction) and mLearning. These three methods are interrelated, and at times overlap into each other. This article focusses on mLearning. For this paper, the terms mLearning and mobile learning will be used interchangeably. The next part of the article looks at the adoption and implementation of mLearning in South Africa and beyond.

3. GOING MOBILE: THE IMPLEMENTATION OF MOBILE LEARNING IN SOUTH AFRICA AND BEYOND

Research shows that South Africa is the leading innovator in Africa in terms of social networking, microblogging, and content creation (United Nations Children's Fund, 2012). Such findings place South Africa at an advantage regarding the adoption and implementation of mobile learning. Although mobile learning has a very short history in South Africa, there has been a rise on its uptake in recent years. A growing range of mobile offerings, including applications and curriculum-supporting websites, is changing the way students interact with learning material (Ngubeni, 2014). The provisions of supporting mobile devices, data and websites have seen a widespread in the penetration of mLearning across the terrain of the education and training sector. This development is boosted by the South African mobile broadband coverage which is showing the fastest growth on the continent (Beyer, 2020). Beyer (2020) also noted that there was an unprecedented growth in mobile learning that is tied with increased internet and platform coverage, as well as other technological improvements throughout South Africa. Mobile technologies have replaced different tools such as desktop computers, daily newspapers, Digital Versatile Discs, college backpacks, and pocket foreign language dictionaries on which people can learn (Mims, 2012; Qualman, 2016).

In South Africa, mobile learning was first applied in 2009 in a project called Multilingual Technology to Support Learning (Beyer, 2020). The programme was specifically aimed at teaching people suffering from dyslexia. The principle was to use voice technology in mobile phones to train building construction employees in both isiXhosa and English. Originating from Denmark, the project was one of the earliest examples of how mobile learning can support teaching and learning (UNESCO, 2012). Another project: the Dr. Maths initiative demonstrated how mobile learning could be used as a teaching and learning methodology. Dr. Maths was launched by the Meraka Institute, which formed part of the South African Council for Scientific and Industrial Research (Vosloo & Botha, 2009). Lecturers and tutors used desktops to communicate with high school learners who were using their mobile phones to engage with Mathematics-related problems (Butgereit, 2012). Another example was the uploading of books to mobile phones. One such successful initiative sought to increase literacy in South Africa by making books available in multiple languages for m-reading (UNESCO, 2012). Users of the system were able to download the novels onto their mobile phones and access the novels in both languages. The users would then provide responses on their perspectives after reading those novels. South Africa's classrooms are characterised by a wide variety of cultural and linguistic differences, providing teachers with educational challenges, particularly in Mathematics and science subjects (Aluko, 2017). In response, various mobile learning systems have been developed and piloted in the North West and Gauteng Provinces of South Africa (Aluko, 2017). Jantjies and Joy (2016) noted that despite the challenges faced by South African teachers in using technology to support learning, devices such as mobile phones, tablets and other similar mobile platforms had been used to demonstrate the potential of integrating technology into learning.

The assimilation of mobile phones and tablets in education and training is not restricted to South Africa but is visible in many countries that have experienced increasing mobile phone penetration. Mobile learning has been used across the world to offer a platform for teaching and learning (Pimmer, Brysiewicz, Linxen, Walters, Chipps & Gröhbiel, 2014). The potential of Information and Communications Technology (ICT) in education has already been acknowledged and highlighted in the Education 2030 Framework for Action, Sustainable Development Goal 4. The framework notes that: "ICT must be harnessed to strengthen education systems, disseminate knowledge, provide access to information, promote quality and effective learning, and deliver services more efficiently (UNESCO, 2017). *Best Practices in Mobile Learning*, a project launched in 2016 aimed to guide the use of mobile learning to create inclusive and equitable learning environments and, at the same time, ensure the quality, effectiveness, and relevance of education for a digital world (UNESCO, 2016). The project shares examples of successful school-wide mobile learning models, presenting lessons learned, and developing a guiding framework that aims to promote future e-school models towards achieving the targets of Sustainable Development Goal 4 (UNESCO, 2017). The United Nations Educational, Scientific and Cultural Organisation (2013) came up with guidelines on enabling mLearning in education. The guidelines were meant to assist learning institutions and organisations in the adoption and implementation of mLearning, having realised the benefits associated with the pedagogy. This paper will illuminate such associated benefits.

4. APPLYING THE THEORY OF SOCIAL CONSTRUCTIVISM AND THEORY OF OPTIMAL EXPERIENCE

Any study meriting serious attention should thoroughly explain the theoretical lenses that inform its perspective. Such a theoretical scaffold has the task of illuminating the authority of argument and the energy with which that research claims authority. The study on which this article draws, was guided by Vygotsky (1978)'s social constructivism theory and Csikszentmihalyi (1970)'s optimal experience theory. This article will apply these theories as a framework to illuminate the benefits of mobile learning and argue for its adoption and implementation in TVET colleges. The social constructivism theory interprets mobile learning as a powerful pedagogy which motivates learners to keep learning using the tools produced socially, culturally, and technologically (Baharom, 2013). The study applied the social constructivism approach to describe how education and training, as a product of human interaction, is acquired through technologically designed tools such as phones, tablets, laptops, etc. The study grounded mobile learning on constructivism tenets, attempting to define a new scope for constructivism: mobile constructivism. According to Baharom (2013), the cardinal argument of social constructivism is that knowledge is mediated by tools or artefacts produced socially, culturally, or technologically with which the learner can engage in learning. The theory of optimal experience was used to demonstrate how mobile learning kept learners engaged in learning with total involvement, making training enjoyable and beneficial. Schmidt (2010) posited that mobile learning is characterised by a deep concentration on and engagement in the activity with an intense sense of control, interest, and enjoyment. The study chose these two approaches because they present a distinct and realistic understanding of mobile learning through interpreting it as a pedagogy which enhances learning in the modern era categorised by 4IR, AI and the endless times of uncertainties. We cannot understand mobile learning if we theoretically and conceptually separate it from pedagogy, educational processes, 4IR, AI and times of uncertainties of which it should be a part. These two perspectives allow for a deeper understanding of mobile learning and its benefits in the South African TVET colleges.

5. THE APPLIED METHODOLOGY

This article draws on a case study conducted in June 2022. Applying a qualitative research design, the case study sought to illuminate the benefits of mobile learning in TVET colleges. It also sought to advocate for the use of mobile learning as a pedagogy in TVET colleges, challenging the hegemony of the conventional Eurocentric approaches to education and training. With this purpose, it followed Terre Blanche and Durrheim (2002)'s guidelines on how to conduct a case study. To the study, 50 (25 males and 25 females) learners and staff from a campus of the public TVET college under study were purposively sampled. The sampling was applied across the four courses (Human Resource Management, Office Administration, Primary Agriculture and Public Management) offered by the campus. Ten student participants from each course (05 males and 05 females), seven lecturer participants from the campus, and three participants from the college management team were chosen.

It is important to note that the college under-study had introduced online learning in all its campuses in response to the impact of the Covid-19 pandemic. The college had to promote the use of mLearning in campuses located in areas with poor internet connectivity upon realising that some learners were struggling to access education and training processes online. It provided some learners with tablets to access education and training through mLearning. The lecturers were given laptops and Wi-Fi routers which were to be loaded with 50G Vodacom data every month. The learners used the devices to send and receive content, instructions and other relevant material from staff and fellow learners. The learners who had internet connectivity continued with online learning while using mLearning as a complementary method of instruction. The online and mLearning methods were used for education and training purposes only and not for examinations purposes. The study did not consider subjects from other campuses and other pedagogies such as e-learning, online learning, or traditional methodologies because this would have widened the scope of the study. For the same reason, the study did not consider other mobile learning aspects such as challenges, disadvantages, and other aspects related to mobile learning.

The study used the self-administered (delivering and collection) questionnaire and semi-structured interview methods to collect data from the participants. The researcher hand-delivered 50 questionnaires, each to the participant at the campus. A total of 30 participants from the constituted sample were interviewed by this researcher. The interviewer spent three days interviewing the participants. The questionnaire and interview questions sought to ferret the benefits and best practices of mobile learning in the college. Content analysis, a method used to systematically analyse the meaning of collected information (Terre Blanche & Durrheim, 2002) was used to qualitatively analyse the data. Of central interest were the core themes that the participants referred to – the information or message that they wanted to pass on. Thematic data analysis approach was used where simple counting of the questionnaire responses and finding patterns in the qualitative data where many participants referred to similar trends of the challenges and strategies meant to overcome those challenges. The similar trends were developed into themes that were analysed and presented as data. In presenting the findings of the study, pseudonyms were used to protect the identity of the participants and institution where necessary.

6. THE RESEARCH FINDINGS

6.1 The Benefits of Mobile Learning in TVET Colleges

The case for mobile learning is commonly made in terms of the benefits that the learners and the education sector accrue. The study which informs this article sought to identify the benefits of mobile learning in the TVET colleges. Previous studies (Kraut, 2013; Mims, 2012; Muwanga, 2009; Qualman, 2016) indicated that there were benefits associated with mLearning which included the ability to learn anytime, anywhere; assisting learners with disabilities and that it built new communities of learners. In addition to the benefits afforded by mobile learning found by the identified studies, this study found that mobile learning 1) increased learner engagement in education and training, 2) promoted accessibility to education and training, 3) was cost-effective, and that 4) there was a high retention of learners in education and training as well as that of knowledge. The same study also made some encouraging finding that: mobile learning led to a continuous engagement to education and training by the learners, a development which led to improved focus on studies-an ingredient for high pass rates. The fact that mobile learning made learner want to engage in education and training continuously, something which led to improved focus on studies and good results made the finding interesting and encouraging. This encouraging finding will form part of an argument for the adoption and implementation of mobile learning in the TVET training processes which will ensue after the presentation of the following findings.

6.1.1More accessibility to education and training

Many participants in the study indicated that mobile learning promoted access to education and training. Nomzamo, a lecturer participant, said:

Having access to training modules through the device which the student is already using is essential. Furthermore, loading learning content into the device used by the learners makes learning more accessible. Most learners have smart phones so by loading content on their phones is the best way to ensure everybody is on board. It was found that some of the learners who used mobile learning had more access to education and training. The participants said that even in the times of crisis, when the college was closed because of the Covid-19 pandemic lockdown restrictions, mobile learning provided a window in terms of accessing education and training. This is in line with Qualman (2016) who found that mobile learning enabled education and training anywhere, anytime.

6.1.2 Increased learner engagement in education and training

The participants in the study indicated that mobile learning led to improved learner engagement. All the lecturer-participants concurred with this finding. Mnyaka said:

The major benefit from mobile learning is the frequent and fruitful learner engagement. Uploading training material and other fascinating activities into the phone or laptop makes for a training experience that is quick and painless. It helps to engage learners and keep them motivated. Learners can take their phones, quickly complete the lesson, and then get back straight to what they were doing. This means that learning becomes a part to their social networking routines, and the learners can immediately see the value of it, leading to increased learner motivation and engagement.

In the study, all the participating students indicated that they enjoyed using mobile learning as a training method. 'I really enjoy using my cell phone to study. It keeps me engaged as I study, just like I do when I'm socialising with my friends', said Zinhle. Zinhle was not the only student who felt mobile learning was engaging. There were other students and lecturers who felt that they could spend the whole day on their cell phones doing schoolwork and socialising, an indication that the learners and lecturers preferred mobile learning. Mnyaka's views reflects Kraut (2013)'s finding that mobile learning promoted learner engagement in learning. This finding aligns well with the Csikszentmihalyi' s optimal experience theory which postulates that mobile learning could keep learners engaged in learning (Schmidt, 2010). It is a benefit which should drive education and training practitioners into adopting and implementing mobile learning as a part to the training practices.

6.1.3 The Cost-effective benefit

Another benefit raised by the participants was that mobile learning reduced the costs of producing learning material. In this study, some lecturers indicated that mobile learning led to decreased costs. As Acwengile, a lecturer, put it:

Mobile learning is cheaper and easier to use than the other conventional training methods. Take for instance; where I used to print dozens of question papers or write notes on the board, I just ask my learners to take pictures of the questions or notes so that they save them in their phones. I would have saved a lot of money on printing toner and printing paper. Gone are the days of photocopying chunks of question papers, textbooks and writing on the board from corner to corner. Smartphones are now at the centre of our lives, and learning is no exception.

This benefit was also identified at college management level where they alluded to the fact that mobile learning, if well adopted and implemented, was cost-effective. According to Nyabali, a senior manager in the college under study; switching to mobile learning had seen a significant cut in printing and photocopying costs in the college. This finding resonates well with Iqbal and Bhatti (2020) who observed that mobile learning reduced costs associated with learning material development and purchase.

6.1.4 High retention of learners in education and training

Another benefit of mobile learning is the promotion of learner retention in the education and training system as well as knowledge retention by individual learners. One of the lecturer participants, Cumisa said:

One of the greatest benefits of mobile learning which many people seem not to realise is that it leads to better knowledge retention in our learners. Training them through mobile devices can improve knowledge retention because we include content such as animations, videos, and games as brief sessions. Brief content increases information retention as the learners can master content they learn in smaller chunks.

The management participants indicated that mobile learning had seen a high retention rate concerning learner training. Velaphi, a senior manager, said:

Since the intensive push for mobile learning and other methods which use the internet in our institution during the Covid-19 pandemic, we have witnessed a high retention rate, with less learner dropouts. This was not the case before, where we had high learner dropout rates as accessing education and training became more difficult due to the imposed lockdown restrictions.

This benefit was not only unique to the TVET sector but also beneficial from a business perspective. Studies such as (Gupta, 2021), indicated that more than half of business leaders saw improved growth after implementing mLearning into their employee training programs, as it not only improved productivity, but also boosted retention.

6.1.5 Learner continuous engagement in education and training processes

Another encouraging finding was that mobile learning led to continuous studying by the learners, like they were 'now addicted to learning' as described by one lecturer in an interview with this researcher. It was encouraging because the opposite of this development is what would be expected-absenteeism, lack of concentration in class and less focus on educational matters. It is alleged that modern day learners are addicted to the social media for non-academic reasons, and this often led them into not focussing on their studies. It is an encouraging finding for education and training practitioners because it comes as a solution to the challenges related to loss of focus on studies as learners become addicted to social media platforms. Most participants concurred that they had observed many students enjoying learning through learning enablers such as cell phones, tablets, and laptops. The participants observed that mobile gadgets kept the learners busy all day as they learnt through their mobile devices most of the times. One lecturer said:

Millennials do not just use their mobile phones nowadays; they are attached to them. The easy way to make them learn is through the mobile devices they are addicted to. This is why it makes sense when people say the easiest way to reach the modern learner is through the device that they use and rely upon the most – mobile phones.

The participant's view was echoed by other participants who observed that learner participation in education and training had greatly improved as learners are always consulting and engaging through mobile devices. This finding resonates well with Muwanga (2009)'s observation that mobile learning kept the learners glued to their mobile gadgets.

All the lecturing and management participants indicated that the increased access to education and training, increased learner engagement, and high retention rates had led to better academic results in their institution. Mobile learning had become a plus for their institution. The participants indicated that mobile learning had opened for them, pathways to education and training processes especially during the Covid-19 pandemic. They continued to enjoy education and training through mobile learning despite the signs that the pandemic was no longer a threat. The participants encouraged the college to adopt and implement mobile learning across all campuses so that the benefits of mobile learning are enjoyed by every learner and lecturer.

7. AN ARGUMENT FOR MOBILE LEARNING

This argument is set against the backdrop of the Fourth Industrial Revolution, and the persistent times of uncertainties which disrupt access to education and training facilities and processes. The times of uncertainties have rendered the conventional-traditional pedagogies inapplicable-a case being the Covid-19 pandemic which stopped face-to-face education and training (Thomas, 2020). In a bid to manage the crisis brought upon by the times of uncertainties and to exploit the opportunities presented by the 4IR, many tertiary institutions are adopting and implementing ICT-supported methods such as eLearning, online learning, mLearning among other approaches (Beyer, 2017). However, mobile learning seems to be the most convenient because it is cheaper, easy to use, and it can be used anywhere anytime, including the remote disadvantaged areas. The fact that mLearning can provide learning to anyone in the country in both remote and urban areas, and that it uses phones to provide the lessons, makes it a better option. This is the same mobile learning approach which was previously thought to be limiting and was not shared in the occupational learning and higher education as a priority.As alluded to elsewhere in this article, mobile learning is relatively new in South Africa. For many years, the Eurocentric methodologies had enjoyed a monopoly in the delivery of education and training. Many education and training institutions solely relied on these methodologies in delivering lessons. However, the persisting crises such as cyclones and associated floods, pandemics such as Covid-19, natural disasters such as earthquakes, civil unrests and load shedding have seen these conventional teaching and learning methods losing their hegemonic status. These methods rely on face-to-face interaction in the classroom so when learning institutions are closed due to the times of uncertainties, they become obsolete. The need to access education and training during such times has resulted in the questioning of the monopoly and dominance of these conventional approaches which insinuate that, without such approaches, there can be no education and training. This study confirmed that mobile learning ensures continuous education and anywhere anytime; even during the times of uncertainties as found by other studies (Kraut, 2013). There is a need for a critical analysis of the education and training methodologies as they exist in the new world order and not only focus on the medieval methodologies, hence this argument.

This part of the article argues that mobile learning is one of the most applicable methodologies in an education and training landscape characterised by frequent training stoppages due to the many huddles posed by the challenging times. The article argues that it makes little sense to solely rely on pedagogies which operate on a stop-and-go pace when faced with adversity. That aside; we are living and learning in the 4IR era so there is a need to go mobile, equipping learners with technological skills to meet the demands of the 4IR. Inferring from the interview findings conducted by this study, most of the learners preferred to be trained through mobile learning. The study found that most learners used tablets provided by the college to access education and training processes during the Covid-19 pandemic, a finding also made by Samad, Ihsan and Khalid (2021) in Malaysia. The need to study and pass their examinations determined how these learners used their mobile devices to study. The interviews revealed that these learners received tablets and data which they used to access education and training. Besides the mobile devices provided by the college, most of the students in the college under study had their own phones with internet capability. The results from this study show that the learners achieved their goals because they were able to study and pass their examinations and then progress to the next levels of education and training. Some of them are now graduates with certificates and diplomas. Although Thomas (2020) noted that the physical shut down of educational institutions during Covid-19 halted most of the students' education and training leaving many learners struggling to access education and training; most students under study managed to access education and training through mLearning. This disputes the narrative that the Eurocentric pedagogy is the most relevant method in distributing knowledge, skills, and attitudes among the learners. Mobile learning as a pedagogy, withstood the Covid-19 challenge, to challenge the hegemony of the traditional conventional Eurocentric pedagogy and delivered the results where some methods failed. Against all the odds stacked against them by the Covid-19 lockdown restrictions, the learners were motivated to keep learning using the tools produced socially, culturally, and technologically.

This argument resonates with Vygotsky's social constructivism perspective as outlined by Baharom's (2013) when the Covid-19 restrictions left the learners with no choice but to use phones, tablets, and laptops to study. They were motivated to continue engaging in their studies so that they would pass. Csikszentmihalyi' s optimal experience, which portrays mobile learning as characterised by a deep concentration on and engagement in the activity with intense sense of control, interest and enjoyment (Schmidt, 2010), aligns well with the idea that mobile learning motivated learners to continuously engage in education and training processes. The learners concentrated and engaged in their studies with intense sense of control, interest and enjoyment. They believed that they would pass their examinations, and with that belief they passed those examinations. Their studies were less depended on the Eurocentric methods of education and training. The desire to study and pass so that they would have a better life served as an impetus for the learners to successfully use mobile learning as a method of learning. Although these learners encountered a host of challenges, mobile learning afforded them the benefits which made them successful. However, there is a minority group of learners who struggle to get the devices either because they do not qualify or cannot afford to buy them. Further studies are needed, to find ways to assist this minority students.

This argument is not in dispute with the fact that mobile learning has got its own limitations in the teaching and learning practices which need to be addressed-limitations such as distractions to learning, smaller screens, network issues, gender discrimination in access to the gadgets, learners who do not have the mobile devices for different reasons, *inter alia*, with some scholars (Winthrop & Smith, 2012) warning of the need to be cautious when adopting technologies for education. The purpose is to highlight that there is a need for a pedagogical shift in the education and training curriculum, considering approaches such as mLearning which enable education and training anywhere and anytime. The traditional thinking that mobile learning is limiting and has no space in the curriculum, is incompatible with the demands of the current education dynamics and does not apply to the education and training pedagogy of the existing world. There is need to change approaches, attitudes, and perceptions about mobile learning not only for a better understanding of education and training pedagogy in the face of 4IR and times of uncertainties, but for its adoption and implementation.

8. CONCLUSION

This article indicated that the increased learner engagement in education and training, accessibility to education and training, being cost-effective, and a high retention of learners in education and training were the main benefits of mobile learning. These findings were supported by other studies which indicated that mobile learning offered numerous benefits to education and training institutions. Guided by the social constructivism and optimal experience approaches, and applying a qualitative case study, the study which informed this article found that the TVET learners at a college in the Eastern Cape Province of South Africa used mobile devices such as smart phones, tablets, and laptops to access education and training processes, engaging with their peers, tutors, and lecturers. These engagements led to improved focus on studies, high learner retention rate, and ultimately, good results. This paper also pointed out that, although mobile learning had benefits, it had limitations which needed further studies to find solutions to address them.

There is a need to adopt and implement mobile learning full time in the education and training field so that it can be blended with other methods such as eLearning, online learning and the conventional traditional pedagogies to have a hybrid pedagogy which ensures continuous education and training. The article attempted to show that mobile learning can be a solution to a myriad of challenges posed by the times of uncertainties and produce great results. The TVET colleges, in conjunction with the Department of Higher Education (DHET) should adopt and implement mobile learning in the tertiary education sector in line with the themes from UNESCO (2013)'s policy guidelines for mobile learning among other considerations. There must be no policy vacuum regarding the use of mobile learning. The authorities in the DHET must craft policy statements that talk to mobile learning advocacy, adoption, and implementation at both governmental and institutional levels. These relevant institutions must upscale the provision of mobile devices and data to cover all programs to enable learners to access education and training. The DHET and TVET colleges can engage experts who train lecturers the best practices of mobile learning. The lecturers could be workshopped on how to apply mobile learning as a pedagogy, and a pathway to learning. Such an approach by the DHET and colleges could yield more benefits, for the learners, the lecturers, the colleges, DHET and the country.

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PE(E)RFECTLY SKILLED: PROFICIENTLY SKILLED IN LEGAL PLEAS, EVEN WITHOUT A TEACHER? STUDENTS' PERCEPTIONS OF THE EFFECTIVENESS, EFFICIENCY, AND ATTRACTIVENESS OF FEEDBACK VARIANTS WITHIN AN ONLINE SKILLS TRAINING METHOD IN HIGHER EDUCATION

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ABSTRACT

This paper reports results of a qualitative study on sophomore students' online experiences with using the Pe(e)rfectly Skilled (PS-) method to train their pleading skills at two universities (regular and distance learning university). The PS-method is an online, interactive, and practice-oriented method for complex skills training, facilitating formative assessment, reflection and (self-, peer and expert) feedback using (video-enhanced) analytical rubrics and self-regulation support. This method facilitates more frequent and highly structured (peer)feedback, so that students can consciously focus their practicing efforts on the mastery of specific subskills. At the same time, it intends to reduce teachers' support burden. Participating students from two different Dutch universities received either both teacher and peer feedback (TP) or only peer feedback (P) while practicing their legal presentations ('pleas') with the PS-method. Afterwards, groupwise as well as individual interviews were conducted with a random selection of participating students (6 TP interviews (13 students), 9 P interviews (17 students). In these interviews, students were asked about their experiences with the overall method, focusing on its perceived effectiveness, efficiency, and attractiveness. Additionally, we explored whether students who didn't receive teacher feedback perceived the method as effective, efficient, and attractive as students receiving both teacher-and-peer feedback. Moreover, their suggestions for improvements of future versions of the method were collected. Transcripts of these interviews were analysed with a coding scheme, that was first validated through an inter-rater reliability test. Results showed that in general, students perceive and experience the PS-method both as effective as well as efficient, although teacher feedback is more readily accepted than peer feedback. Moreover, students overall also enjoy working with the method. Additionally, no important differences in perceived effectiveness and attractiveness were detected related to feedback variants, although for perceived efficiency both feedback variant as well as the type of university seemed to matter.

Keywords: Online skills training; complex skills; formative assessment; (peer)feedback; reflection; self-regulated learning; (video-enhanced) rubrics; higher education; distance education

1. INTRODUCTION

Training (legal) presentation skills (i.e., pleading) requires, in addition to a lot of repetitive practice by students, also support, like constructive feedback and structure (Vincent-Wayne & Bakewell, 1995). Feedback during the practice process is a powerful tool for teachers to support skills training (Hattie & Timperley, 2007; Kirschner & Van Merriënboer, 2008; Planar & Moya, 2016; Shute, 2008), however a growing number of students makes it increasingly challenging to provide individual and personalized feedback on time (Allan & Bentley, 2012; Planar & Moya, 2016). While the number of first-year students at Dutch universities has increased by more than 55% since 2010, the growth in teaching staff is only 28% (CBS, 2021). Additionally, only recently UNESCO (2023) sounded the alarm on a global teacher shortage, indicating teacher capacity is increasingly a problem at an (inter)national level. While it is still the teacher's task to provide support and interact with students in learning activities, students' active role and the type of learning activities they perform appear to be the most important predictors of students' learning achievements. Even if compared to teachers' activities (Biggs, 2003, p.23). Moreover, the increased attention and space in educational policy for a more central role of students' learning processes and experiences in education opens possibilities for other types of learning activities, such as peer feedback (Vincent-Wayne & Bakewell, 1995). Formulating peer feedback requires students to engage actively, both at a cognitive as well as a more personal and emotional level and can contribute to knowledge construction (Filius, 2019). That is why peer feedback could have an added value as an effective learning activity, as well as potentially save teacher time (Filius, 2019; Nicol, 2010).

The online Pe(e)rfectly Skilled (PS-) method guides students step by step in developing their complex skills, such as legal presenting, by systematically supporting self-, peer- and expert feedback processes. Moreover, PS- is interactive and practice-oriented, facilitates formative assessment, reflection, and self-regulation support using (video-enhanced) analytical rubrics (Rusman & Nadolski, 2023) and data visualizations of their skill performance progress. Behavioral aspects of skills are illustrated via video-enhanced rubrics and video modeling examples (Ackermans et al., 2021; Rusman et al., 2019; Rusman, 2020; Rusman & Nadolski, 2021). Feedback on students' performance level by various feedback providers is visualized, throughout time, in a 'skills' wheel (see Figure 1). Through this PS-method, students are supported to go through several cyclic (formative assessment, feedback, and reflection) processes in a structured and stepwise manner, fully supported online in a so-called PS-tool. Thus, the method supports more frequent and highly structured (peer)feedback, helping students to gain insight in where their skill performance level may still be improved, so that students can consciously focus their practicing efforts on the mastery of specific subskills. In this study, sophomore students' perceived effectiveness, efficiency, and attractiveness of the PS-method to train complex legal pleading skills online was evaluated. Moreover, the perceived value of teacher feedback compared to peer feedback only was determined. The following research questions stood central: *What are students' perceptions of the effectiveness, efficiency, and attractiveness of the PS-method to train* *complex pleading skills? Are their perceptions dependent on the feedback variant (peer-and teacher feedback; only peer feedback) they received? Is teacher feedback perceived as essential to support students' skills training?*

Feedback is automatically summarized and displayed in the skills wheel and compared to students' previous performance. Students can see where performance of a subskill can still be improved as an indent in the wheel. Each 'spoke' of the wheel represents a subskill, and each block in a spoke represents a performance level. If performance improved (compared to previous practice), a subskill becomes bright green; when it faltered it turns red.

Figure 1 – Visualization of received feedback and students' performance level on subskills through time in the 'skills' wheel.

2. METHODOLOGY

A qualitative study was set up to evaluate the effectiveness, efficiency, and attractiveness of the PS-method to train complex pleading skills online in two universities (Open University of the Netherlands (OU) as a distance learning university and Maastricht University (UM) as a blended University). Additionally, it was explored whether students perceived teacher feedback as an essential element for their skills mastery, or whether teacher feedback could be left out or reduced. Therefore, in-depth online interviews with students were used to explore their experiences (Cresswell, 2014, p. 30).

In total 264 sophomore students (207 UM and 57 OU) in both Faculties of Law participated in the overall study. The students within each university were divided in two experimental groups: they either received Teacher, Peer, and Self-feedback (TP) directly on their performances or received Peer and Self feedback (P) directly and received delayed teacher feedback at the studies completion. All students who participated were informed about the study and were able to indicate their wish to participate via an informed consent. From this overall group of students, a group of students (n=30) was randomly selected from the list (alphabetized), with whom interviews were conducted via MS Teams, approximately equally divided (17 P and 13 TP) over both conditions and across universities (13 OU and 17 UM). The interviews with the students took place individually, in duos or in trios. All interviews lasted between 50 to 60 minutes.

The online interviews were semi-structured via an interview scheme (Appendix A, available upon request). All interviews were recorded and transcribed and for the interviews with multiple people cut into interview responses per person. To analyze the student interviews a coding scheme was developed. The process for developing the coding scheme consisted of four steps:

1. All interviews were broadly explored to gain an overall picture, generate ideas, and organize the data (Creswell, 2014). These insights, combined with both theoretical knowledge as well as the

objectives of the study, led to a first version of the coding schemes. The main concepts and associated labels were divided into categories and subcategories with corresponding codes and descriptions, with values added to represent positive (+), neutral (- +), or negative (-) experiences.

2. The coding scheme was then tested with three interviews. Based on this first test, the coding scheme was updated: codes were added, modified, or removed.
3. In the third step, the updated coding scheme was applied by one of the researchers and an independent second coder, who was not involved in the study. Based on the results and feedback from the second coder, the coding scheme and adhering descriptions and instruction were further improved.
4. In the last step, the application of the coding scheme by two independent coders was compared by means of the Krippendorff's alpha binary value (Krippendorff, 2004). This provided insight into the extent to which the coders reached agreement when assigning statements to categories. The reliability of the coding schemes was examined by applying them in to two interviews, using selected statements (predefined quotes). The inter-coder agreement coefficient was determined for each semantic domain in the scheme and the Krippendorff's alpha binary values (Krippendorff, 2019) were interpreted according to the recommended reference values: $\alpha < .667$ (unacceptable), $.667 \geq \alpha < .800$ (acceptable for preliminary conclusions) $\alpha \geq .800$ (acceptable), $\alpha = 1.000$ (ideal). The coding scheme had an acceptable to ideal acceptable inter-coder agreement coefficient (variables = $.780 \geq \alpha \leq .995$), except for the "experienced competence development" category, where the reliability was unacceptable. After analyzing the differences in coding between the two coders, it was discovered that the second coder had linked statements about the emergence or improvement of the mental model to the “perceived utility” of the PV method code instead of the “competence development” code. The instructions were modified based on these findings, and both coders reached agreement in the final coding exercise. Appendix B (, available upon request) contains the main coding concepts and (an excerpt of) the resulting coding scheme.

Based on the final coding scheme, all interviews were coded by one researcher with Qualitative Data Analysis software Atlas.ti version 26. The unit of analysis was on answer level and multiple codes per (selection of an) answer were possible. Herewith both quantitative and qualitative data were derived. Overviews were generated that indicated whether a student made statements that could be related to a specific code at least once or not at all. To calculate percentages, the number of statements per concept within a code group/category were considered. If specific students did not make any statements within a code group, category or concept, these students were excluded from the count to calculate a percentage: the remaining number of students were considered as 100%. Furthermore, a normative comparison was made at the variable level between positive and negative statements per variable. This approach was chosen because questions often overlapped, resulting in students frequently repeating arguments. To gain further insight, also quotes belonging to subcodes were analyzed. Percentages were calculated by plotting the number of unique statements per person within the relevant subcode against the total number of unique statements per person.

3. RESULTS

Students' perceived effectiveness of the Pe(e)rfectly Skilled (PS-) method

The perceived effectiveness was determined based on three criteria: 1) students' experienced competence development, 2) the perceived usefulness of the (various steps of the) PS method and 3) the perceived usefulness of the feedback in general, peer feedback and/or teacher feedback. Even though 100% of the interviewed students (30) experienced the method as effective, 90% of the students indicated that they experienced the method about some aspects as ineffective. It was therefore further investigated to what degree the three criteria were perceived as most or least effective and which arguments were mentioned.

1st effectiveness criterion: perceived competence development - Students competence development was indicated by 1) a rich(er) mental model of a skill; 2) development of feedback skills; 3) development of pleading skills and 4) an increase of self-confidence. Students (n=29) experienced this overall criterion as positive: 97% indicated that they have developed themselves, compared to only 3% who indicated that they have not developed themselves in one or more areas. Most students indicate that they feel that they have developed their pleading skills and have a better image and mental model of such skills, respectively 86% and 83%. In addition, 55% of students felt that they have more self-confidence and 38% indicated that their feedback skills have been developed. These findings are illustrated in Table 1 by some exemplary quotes.

Table 1 – exemplary codes illustrating students' perceived competence development.

Criteria	Exemplary quotes
Rich(er) mental model of skill	*I'm sure my first video [plea] was a lot worse than my last video. So, I really learned a lot in that regard* (Respondent #10 duo speaker 2)
Development of pleading skills	*You mainly got to see... "a good person will do this and this", through given examples. And a person who doesn't do that well... you got to see this from good to bad, so to speak, there were steps in between. Because they had already given examples, you could also get a better picture of "this is a good plea/this is a bad plea" (Respondent #1 solo)*
Development of feedback skills	*I also just think that during the [feedback] process, that you saw improvement in it, in that giving. And I think everyone also thought, you know [that they knew] how to give feedback, but I also enjoyed seeing how others did it, and that you indeed just learn from each other, which is nice. What you like to receive is also nice to give back, and with that rubric it was very easy to pick up on a certain point, and then you only had to put it into words* (Respondent #5 trio speaker 2)
Increase of self-confidence	*I had concluded for myself "I can do certain things, but I [also] can't do certain things, and that is presenting. And now I think, well, maybe I should do that more often. Because I can, I'm pretty good when I have a story, that doesn't look bad at all. In that sense it really helped me, I'm very positively surprised* (Respondent #9 solo)

Note: some editorial additions are indicated between [brackets]

2nd effectiveness criterion - perceived usefulness of the Pe(e)rfectly Skilled (PS)-method - Students' perceived usefulness of the complete and/or various steps within the method was assessed positively by all (100%) of the students ($n = 30$). The most frequently cited argument (70%) in support of positive findings is repetitive practice; 60% of the students also mention the structured, step-by-step approach and 53% the available information and instruction in the method. Of the five steps that the students go through, step 2 is especially experienced as useful by 77%, step 3 by 90% and step 4 by 53% of the students. Step 1 and step 5 were not mentioned as often, compared to the other steps. These findings are in Table 2 illustrated with some exemplary quotes.

Table 2 – exemplary codes illustrating students' perceived usefulness of the (PS)-method.

Criteria	Exemplary quotes
Repetitive practice	*Because I think this is the way to do it. Practice, look back, receive feedback, do something with it. And then do it a few times more* (Respondent #2 solo)
Structured, step-by-step approach	*I found the structure very logical and the way of working as well. That gave a structured picture. You just make your presentation first, try to take an example from the videos of [other] students and the examples, the feedback too, and you also take that with you when you get it again. So, I just liked the way it was put together (*Respondent #8 duo speaker 3)
Information and instruction	*... yes, you just get very clear instructions, also very extensive, you know exactly what to do. You must read everything first, of course, "ok, I have to pay attention to this"* (Respondent #8 duo speaker 2)
Step 2 - practice, record and self-assess	*That you look back on and record yourself and really look back to see how it was. I think that's a strong point. And furthermore... yes, nice example videos of how something should be done and how something is not done well. Sometimes obvious, but then you see yourself doing it anyway, so it is good that you know for sure that that is not the purpose. That's supportive in a nice way* (Respondent #9 solo)
Step 3 - provide peer feedback	*I thought it was nice to keep the example videos next to it, because then you really had an example [with the rubric descriptions] and what you really should be able to see and [compared to] what it [peers' performance] really looked like. So, I thought this was useful comparison material to really look [critically] at the presentation of other students* (Respondent #12 trio speaker 3)
Step 4 – consult feedback	*I found the progress you could see and the skill wheel really motivating. So, when I saw that I found something difficult myself, but that the feedback was good and that another dark green block was added, I was happy for a while* (Respondent #12 trio speaker 3)

Note: some editorial additions are indicated between [brackets]

In contrast to the positive evaluations of students, more than half (63%) of the students also indicated at least once that they did not find (aspects of) the PS-method useful. The argument most often given by students (43%) is that they lack a dialogue opportunity to ask questions about the peer feedback.

An example cites as illustration: "*If there had been a chat function, I'm sure I would have asked for an explanation, like: hey, can you explain in more detail what exactly you mean by …?*" (Respondent #3 duo speaker 3). Other arguments were a lack of an opportunity to provide overarching top-level feedback; the repetition of feedback and practice; the abundance of information; difficult/uncomfortable to self-assess or insufficient perception of quality criteria of good peer feedback. These arguments were given by only 7 to 10% of the students.

3rd effectiveness criterion - perceived usefulness of the feedback - Students' statements about their experiences with received feedback, from their peers and (depending on the condition) from their teacher, gave insight in how they perceived the usefulness of the feedback. Most students evaluated teacher feedback (n = 12) and peer feedback (n = 30) as useful (92% and 80%). On the other hand, 53% did not appreciate peer feedback usefulness and 25% did not find the teacher feedback useful on certain aspects. As arguments for the perceived usefulness of teacher feedback, 58% of the students mentioned the reliability of the source and 50% appreciated the degree of concreteness of feedback. Furthermore, the fact that feedback was critical in nature (17%); the comprehensiveness of the feedback (17%) and expert opinion of the teacher (8%) were mentioned by students. Students' arguments for a negative assessment of the usefulness of peer feedback were the reliability of the source (20%); comprehensiveness of peer feedback (13%), only positive feedback (13%) and peer feedback insufficiently concrete formulated (10%). Nevertheless, 82% of students choose a combination of teacher and peer feedback (only 5% prefer only peer- and 18% only teacher-feedback). Arguments for the combination of teacher and peer feedback for students is that they can combine the reliability of teacher feedback with reiving more feedback through their peers, however also while giving and receiving peer feedback creates a sense of connection with their peers. Finally, a few students indicate that mirroring with the help of peer examples is also of added value. In Table 3, these findings of the preferred choice of the feedback source are supported by some exemplary quotes.

Table 3 – exemplary codes illustrating students' preferences regarding feedback.

Criteria	Exemplary quotes
Trust in feedback source and perceived psychological distance	*I also think that it gives a completely different dynamics if you also work together with [fellow] students. In a sense you must do it together. It also causes social pressure, perhaps, that you think: oh yes, I really must do my best, because it is also very nice for them if I can give them good feedback that they can use, so I really liked that aspect. In terms of the usability of the feedback, I naturally think teacher feedback is a bit more useful than feedback from your peers, because we all don't have that much experience with it yet, but I was very pleased to know that you were really in it together, and that everyone did the same, and that you really took it into account in your feedback like "oh yes, I will also receive feedback from them later, let's take each other to a higher level". I really liked that about it, and found it motivating* (Respondent #5 trio speaker 3)

Criteria	Exemplary quotes
Feedback acceptance and quantity	*I think I like getting different types of feedback. I must say that I benefited more from the teacher feedback, probably while I also accepted it more quickly, because she is more knowledgeable than my peers. But what I said, like that tic, she hadn't noticed, and that fellow student had. And I think in the end it is your overall presentation that is looked at and then I think that the more people assess it, the more it will ultimately help you. It depends on the teacher, but I think it's very nice that four people looked at it instead of one teacher* (Respondent #13 duo speaker 3)
Feedback acceptance and mirroring of performances	*The teacher really looks at it like an assessment, so to speak, and peers really look at it like this: what can you still improve and what could you maybe still improve yourself on looking at what you have seen from another student [performance]. Maybe look a bit at how the other person was doing and then maybe mirror that in your own presentation* (Respondent 12 trio speaker 4)
Feedback quantity (sec)	*Like this it's right for me. Legally, of course, I rely more on a teacher, but in terms of presenting and feedback, yes, the more the merrier, so I think it's good to get feedback from peers as well* (Respondent #11 duo speaker 3)
Mirroring	*So on the one hand I would prefer to receive teacher feedback, but on the other hand, if I have a video from a peer and also receive feedback from peers, I like that a lot better, because in that way you also know about... for example with the pleading note in terms of content, then you already know: I forgot this and I should have put this in better, and that introduction is much more catchy, so I better change it. That you have something like "yes, now I can compare a bit with peers, how they are doing and getting started. And I think that's the best thing about the program, that you can make a comparison with each other: why does his introduction goes so well and why is the ending better, so that he comes across more convincingly? I really like that* (Respondent #4 trio speaker 2)

Students' perceived efficiency of the Pe(e)rfectly Skilled (PS-) method

The perceived efficiency consisted of two criteria: 1) perceived ease of use and 2) experienced required or available time to go through the method. What is striking is that overall, 82% of the students (n = 28) indicated that they experienced the complete method as efficient, however 93% on certain aspects as inefficient. A similar contradictory picture can be seen for the two independent criteria time (+64%, - 68%) and ease of use (+74%, - 89%). Therefore, it was subsequently investigated in more detail which arguments students gave for their positive and negative efficiency experiences.

1st efficiency criterion: perceived ease of use - An analysis of student statements (n = 27) shows that the perceived ease of giving and receiving feedback with the online PS-tool is the most important reason for students (56%) to regard the method as user-friendly. In addition, the overall ease of using the tool (30%) and the proper functioning of the PS-tool (19%) is mentioned as reasons by some of the students. Looking into the negative experiences, the most frequently mentioned reason for 52% of the students appears to be the difficulty of assessing the skill: they find it difficult to recognize sub-skills and then assign them to rubrics and assign a performance level score to them. The use of the PS-tool (for example, not being able to go back to previous steps and/or difficult to upload own recordings) is the reason for the perceived negative ease of use for 48% of the students. For 37%, issues with retrievability and readability of the information (because there is a lot of information, information is easily overlooked) and the user-friendliness of the recording options (30%) – when the default – recommended – Webcam option is not used also play a role in the negative experiences. Table 4 provides some exemplary quotes illustrating these findings.

2nd efficiency criterion: time available or required - After an analysis of the criteria of available or required time, a diffuse picture of student experiences (*n* = 25) emerges. On the one hand students appreciate the required time investment (24%, they agree that the method makes them feel compelled to invest a lot of time in practicing the skill and giving feedback), but on the other hand they think that working with the method takes (too) much time (40%), amongst other things because of the number of practice and feedback rounds. Moreover, students do think they learned a lot in a relatively short time (24%). The perceived time spend in the overall study program itself is independent of the efficiency of the PS-Method, but it seems to influence students' perceived efficiency as 24% of the students also mention this as a limitation in terms of time investment. Dependence on deadlines is not appreciated by 28% (they depend on others and get out of their 'flow'), although other students indicate that they appreciate a 'big stick' to get them through the deadlines. Finally, 12% like the time and place independent character of the method, and finally an equally large percentage of students think the number of feedback and practice rounds is too elaborate. Table 4 contains some exemplary quotes.

Table 4 – exemplary codes illustrating students' perceived efficiency of the (PS)-method.

Criteria	Exemplary quotes
Perceived easy-of-use (+)	
Ease of providing/receiving feedback	*I always had that schedule with those stars next to it and you could just fill [your content-related] comments in and in advance I often also looked at what exactly was being asked* (Respondent #9 solo)
Tool usability	*It was very self-explanatory, which made it very easy for me to do things* (Respondent #13 duo speaker 2)
Technical functioning of tool (+)	*So, it was... refreshing, I would say. That it was done in a different way, with a program that at least worked, because I also remember programs that didn't work, but this one just worked* (Respondent #1 solo)
Perceived easy-of-use (-)	
Recognizing subskills or levels	*I was sometimes thinking "maybe it was more about content than about structure or more about structure than about content [sub-skills in rubric]". That was also a bit of a worry now and then: where shall I put it?* (Respondent #7 duo speaker 3)
Technical functioning of tool (-)	*I think the weakest thing of the method is, this may sound very stupid what I'm going to say now, that you depend on that technical side, and*

Criteria	Exemplary quotes
	when there is some kind of malfunction, for example. (Respondent #8 duo speaker 3)
Abundance of information	*So, I sometimes had to click quite a lot and back and forth, searching, "where was that again, how did I get to that [information/text] again?"* (Respondent #7 duo speaker 2)
User friendliness of video recording functionality	*Practically, I think it is quite difficult to set this up at home. So, I think this is still a point to focus on. I messed around with a household stair. I've tried different things to have that camera position in such a way that you are in a somewhat normal way positioned in the recording, and at the same time still be heard. So, it does require some facilities at home to be able to do this* (Respondent #3 duo speaker 3)
Time available/required (+)	
Time investment (+)	*I really think [you learn] by practice and applying it and, above all, staying engaged with it. So not that you are going to do it very quickly, but that you also take your time* (Respondent #12 trio speaker 4)
Learning process independent of time and place	*And I think if you were to do it physically [f2f], you might have one or two days and then the same thing might come out, but I think because this is spread out over time, and while you're only doing it online, that really helps. In that respect I think it is really a good alternative* (Respondent #10 duo speaker 2)
Time available/required (-)	
Time investment (-)	*I was with three people, so it will take a while to give [them all] extensive feedback. Of course, you first had to listen to all those presentations, then you must go through the rubric for each student. This has taken quite some time* (Respondent #4 trio speaker 2)
Deadlines	*I found it annoying that you had to wait until a deadline had passed, while everyone was already finished* (Respondent #6 duo speaker 3)
Time available	*At least for myself I experienced this course, and I have also heard that from other students, just so heavy in terms of workload and it was therefore then difficult to put in all the time you wanted to put into it* (Respondent #12 trio speaker 2)
Number of practice and feedback cycles	*I found it difficult that there are two [practice] rounds in it. I do understand that it is meant to make progress, of course, so that you practice the same for a second round. But I was like "yes, if I liked my presentation the first time and I only got good feedback on it, why do I have to do it a second time?" Because it's the same. Often it was also that it went less well the second time. Because for the sake of a change*

Criteria	Exemplary quotes
	you just started doing things differently. But then it didn't get any better. At least in my case (Respondent #6 duo speaker 3)

The perceived attractiveness by students - Attractiveness was operationalized in two criteria: 1) the perceived enjoyability to work with the PV method and 2) preference for this form of (online)education. All students (*n* = 28) indicated at least once (100%) that they experienced the method as attractive. However, 54% indicated that they not always appreciated the method, mainly because of its solely online form.

1st attractiveness criterion: perceived enjoyability of the Pe(e)rfectly Skilled (PS-) method - The perceived enjoyability of the PS-Method was derived from students' statements (*n* = 28) referring to perceived pleasure of developing skills/working with the method; their commitment to provide good peer feedback, their desire to use the PS-Method in other courses, or whether they would recommend it to others. The most frequently cited reason for perceived enjoyability is that students indicate that they like/enjoy working with the method and/or that they feel motivated (89%). In addition, 57% indicated that they would like to work with the PS-Method again to develop other skills and 61% would recommend the method to others. Finally, 32% of the students mentioned they really did their best when giving peer feedback. See Table 5 for some illustrative quotes.

2nd perceived attractiveness criterion: preference for this form of (online) education –
This study distinguished between three forms: 1. fully online PS-Method; 2. practicing the PS-Method online with face-to-face presentations or the PS-Method in a blended form, alternating between form 1 and 2. Of all the students who commented on the form of instruction they would prefer for using the PS-Method (n = 26), on the one hand, 69% indicated that they would not have a problem using the PS-Method fully online. On the other hand, 46% of the students indicated a preference not to take fully online instruction if it was not necessary. Finally, 31% indicated a preference for a blended variant, where they would also practice the skill face-to-face. This is illustrated by some exemplary quotes in Table 5.

Table 5 – exemplary codes illustrating students' perceived attractiveness of the (PS)-method.

Criteria	Exemplary quotes
Perceived enjoyability	
Fun/motivating	*I found it fun and refreshing. Yeah, maybe also a little bit while we live in a restricted world now [corona]. Everything goes through a screen and it's kind of awkward. It's quite hard to interact and I really enjoyed doing it in a different way and be engaged in this way through my study. I also remember very well that every time when there had been a deadline, that I was curious about what became available in the method and what had happened, and what my feedback was. I also really looking forward to continuing practicing*

Criteria	Exemplary quotes
	again. So that was just very pleasant, and I think also motivating, that you just kept working on it continuously (Respondent #5 trio speaker 3)
Use in other courses/for training other (type of) skills	*I think the practice part and the feedback part can just help to improve skills and I don't think it really depends on presentation skills, but that it can also help with [practicing] writing or something like that* (Respondent#12 trio speaker 3)
Recommend it to others	*It has helped me a lot and I indeed now do know better what I can improve and what I'm already doing well. So, it did provide a lot of insight. So, I would recommend it to others* (Respondent #12 trio speaker 2)
Effort for peer feedback	*I did try to give very honest peer feedback. Everyone should pay attention to the same points and, above all, make it very concrete. Also, in the beginning of using the pv tool and the tip-top method, it was told that if you give a tip, you also give a top, so that you have a bit of balanced feedback. And, that you must try to make things concrete. And I really tried* (Respondent #14 trio speaker 3)
Preference for this form of (online) education	
Completely online	*I think I have indeed invested more time into it now than if it had just been a live meeting. Now you indeed practice more often, you stop the video and then you start again and that is also part of your learning process. I do think that I have now spent longer developing this than I normally would have done. That's indeed nice!* (Respondent #12 trio speaker 2)
Blended (f2f&online)	*Physically [f2f], the experience is very different than online. So, if you only do it online then you're not going to have the experience you can get when you're in court. So, I think it's good to do it physically once or twice, but indeed combined with feedback and being able to look back, being able to optimize it in the initial phase, which can be done very well online* (Respondent #13 duo speaker 2)

Students' perceived effectiveness, efficiency, and attractiveness of the PS-method in relation to the feedback variant

To determine whether the feedback context influenced students' experiences, quantified perceptions of students who received teacher feedback were compared with students who did not. Also, perceptions of students at the Open University were compared to those of Maastricht University. Comparisons were made by contrasting the percentage of students who made at least one statement appropriate to a code and/or category by context (see Table 6).

Table 6 Comparison of students' experiences between contexts (feedback variant and university)

	P	TP	Positive or negative perception	UM	OU
n =	17	13		17	13
Effectiveness	*n* = 17	*n* = 13		*n* = 17	*n* = 13
	100%	100%	+	100%	100%
	94%	85%	_	82%	100%
Students' perceived competence development	*n* = 16	*n* = 13		*n* = 16	*n* = 13
	94%	100%	+	100%	92%
	13%	8%	_	0%	23%
Perceived usefulness of received peer feedback	*n* = 17	*n* = 13		*n* = 17	*n* = 13
	88%	69%	+	76%	85%
	53%	54%	_	59%	46%
Perceived usefulness of the PS-method	*n* = 17	*n* = 13		*n* = 17	*n* = 13
	100%	100%	+	100%	100%
	71%	54%	_	53%	77%
Efficiency	*n* = 16	*n* = 12		*n* = 15	*n* = 13
	75%	92%	+	73%	92%
	100%	83%	_	93%	93%
Perceived ease of use	*n* = 16	*n* = 11		*n* = 14	*n* = 13
	69%	82%	+	64%	85%
	88%	91%	_	93%	85%
Perceived usage time available /required	*n* = 14	*n* = 11		*n* = 12	*n* = 13
	50%	82%	+	83%	46%
	86%	45%	_	50%	85%
Attractiveness	*n* = 15	*n* = 13		*n* = 16	*n* = 12
	100%	100%	+	100%	100%
	40%	62%	_	63%	33%
Perceived enjoyability	*n* = 17	*n* = 12		*n* = 17	*n* = 12
	182%	100%	+	94%	100%
	6%	8%	_	6%	8%
Preference for this form off (online) education	*n* = 14	*n* = 12		*n* = 16	*n* = 10
	50%	92%	+	56%	90%
	43%	67%	_	63%	36%

Note: P = Students who received peer feedback, TP = Students who received teacher- and peer feedback. UM = Students of Maastricht University, OU = Students of the Open University of the Netherlands.

Looking at the overall percentages at variable level, no striking difference can be seen between both feedback variants. When comparing students' perceptions per feedback variant at category level, the percentage of students who indicated that they had either positive or negative experiences with the required usage time differ with more than 30% between students with and without teacher feedback and between students from the Open university and Maastricht University. Such a difference is also visible in the perceived attractiveness of the full online form of education, with more Maastricht University students perceiving this as negative.

4. FINDINGS AND RECOMMENDATIONS

This study evaluated students' perceptions of the effectiveness, efficiency, and attractiveness of an online method to train the complex skill of legal pleading, named Pe(e)rfectly Skilled. Moreover, it provides an indication whether the feedback variant (peer and teacher feedback or only peer feedback) influenced students' perceptions, to determine whether students perceived teacher feedback as essential for their skills development.

Results indicate that the majority of the interviewed students evaluate the overall use of the method as effective (100%), attractive (100%) and efficient (82%). However, on aspects students' evaluations of the method are not as effective, attractive, and efficient as wished for. Overall, 90% of the interviewees indicate they experienced negative aspects regarding effectiveness, 93% regarding efficiency and 54% concerning its attractiveness. To nuance this picture, the normalized judgments of the effectiveness of the PV method were examined and were found to be positive in nature in 86% of the judgments. Looking at efficiency 40% and for attractiveness 85% of the statements were positive. Students do suggest various ways to further improve the method, for improving efficiency. Suggestions were given to reduce the number of feedback rounds; students would like to have more freedom to set the pace for all steps within their own peer group (e.g. remove fixed deadlines); allowing students more time to practice within the course (e.g. by reducing attention on other components); reducing the amount of explanation/instruction with each step in the method (e.g. through minimalist support approach) and to prevent students from 'getting lost' in the subskills focussing on a selection of subskills instead of all subskills.

Comparing the peer-and-self-feedback group (P) with the peer-self and teacher feedback (TP) group, no striking differences in perceived effectiveness, efficiency, and attractiveness could be found at a general level. However, when looking at the underlying categories, students in the P-group perceived the required time overall as less positive and more negative than the TP group. This may be due to students' spending quite a lot of time providing peer feedback as it is their only feedback source, and they are mutually dependent on it. Additionally, they lack the teacher feedback as a kind of reference framework, potentially making it harder for them to formulate their peer feedback. Moreover, looking at the online form only, OU students are more positive than UM students, which might reflect their overall accustomed to a specific educational form (online, blended or f2f) or the amount of study pressure they perceive in the curriculum.

Looking at the perceived indispensability of teacher feedback compared to the peer feedback a mingled response was visible. Most students (80%) appreciated the peer feedback received, both in terms of quality as well as quantity. In addition, students mentioned that peer feedback helped them to feel connected and to compare themselves to peers, thereby changing and improving their own performance.

However, 53% doubt the reliability of peer feedback. Teachers are seen as a reliable source of feedback, which is why 82% of students prefer a combination of both teacher and peer feedback. Teacher feedback was mainly appreciated as students trusted and accepted the teacher feedback more readily than peer feedback, although in practice in terms of content and suggestions for improvement feedback quality differed not a lot from peer feedback. Teacher feedback mainly seemed to serve as a 'quality stamp' mechanism for students and increased their feedback acceptance, however in terms of content and concrete feedback on their skill performance had less added value compared to peer feedback. However, as feedback acceptance is importance at least some kind of feedback quality control by a teacher seems indispensable.

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A QUANTITATIVE IMPLEMENTATION AND RETENTION STUDY OF LEARNING BY MOBILE PHONE APP

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ABSTRACT

With the intent of combatting the tendency of students to cram for exams, we have studied the implementation and learning effects of a mobile phone-based application. Because it is built on accepted learning strategies, i.e., spaced repetition and retrieval practice, in combination with using push technology, we opted to use and study Cerego. Within this app, students memorize study content and practice with it, e.g., using flashcards, ordering assignments, and clickable maps. The study content is created by the professors of the courses. Student surveys, analysis of metadata from the platform, retention testing. Between 2019 and 2022, three faculties implemented the app in various BSc and MSc courses, and over 3000 students registered to use it. Student surveys indicate that they believe that the app helped them in their studies. They indicate that they would like it to be implemented in more courses of their program. A study on retention effects using two related first-year courses in a chemistry program shows a linear increase in retention with increased use of Cerego. Circumventing a potential selection bias in the second year of study, results indicate that avid Cerego users show a significant increase in retention of practiced material in comparison to an identical group of non-users. The beneficial effect depends non-linearly on the fraction of reached learning goals within the app and has a tipping point at 50% of these learning goals. An analysis of the performance on retention test questions that were unrelated to study materials provided through the learning app suggests a compound learning effect. As benefits to long-term retention are most prominent for students reaching at least 50% of learning goals within the app, the introduction of mobile-phone-based learning should aim to have students reach this limit.

Keywords: mobile learning; application; Cerego; retention; technology acceptance.

1. INTRODUCTION

The application of artificial intelligence in education (AIEd) is becoming increasingly widespread. A recent review of 146 articles published since 2007, categorized these into four application areas, i.e., profiling and prediction, assessment and evaluation, adaptive systems, and personalization, and, finally, intelligent tutoring systems (Zawacki-Richter et al., 2019). The extensive review shows a preponderance for AI applications in the first of these areas, i.e., profiling and prediction. Studies of AI applications that aim to improve student learning are much sparser. Longitudinal studies in this area are indicated to be lacking. Moreover, the connection of AI applications to theoretical pedagogical perspectives is characterized as weak.

To counter unwanted "cramming" as a learning strategy to study for examinations, Leiden University (Leiden, the Netherlands) has recently started piloting an AI-based adaptive learning platform called Cerego. While many students are known to use cramming as a learning strategy to study for examinations (McIntyre and Munson, 2008), from cognitive and learning psychology it is well-known that more efficient learning strategies include spaced repetition and practice testing (Dunlovsky et al, 2013). The influence of the duration of study sessions and the temporal spacing is well-recognized. (Rohrer and Pashler, 2007). Practice testing (or the testing effect) is considered critical in building long-term retention (Roediger and Butler, 2011).

Cerego incorporates the more efficient learning strategies, i.e., spaced repetition and the testing effect (Harlow, 2013), thus providing a clear connection between accepted pedagogical theories and AIEd. Much like digital communication platforms that students are familiar with, Cerego uses push technology. Via push messages, individual students are enticed to study learning content at the most appropriate time intervals to efficiently build long-term retention. The timing of the push messages and what content is (re-)offered through practice testing is determined by an AI-based algorithm and tracking each student's performance. The algorithm attempts to optimize the individual's study efficiency and reach retention goals as defined by the teacher for each set of study content.

Most interesting to Leiden University in the pilot study of the learning platform are two questions:

1. Do students adopt such software to help them memorize if use is voluntary?
2. Does the use by students improve long-term retention?

Other interesting questions, e.g., whether (aspects of) adaptation of this technology varies between academic programs and how information on variations in adaptation can be used to obtain the largest possible learning effect (‘maximizing bang for the buck’), were also considered but not addressed systematically during the 3-year pilot. Such questions border on technology acceptance models, in the context of mobile learning (for recent reviews see e.g., Al-Emran et al., 2018; Granić and Marangunić, 2019). This is beyond our current interest. Herein, we limit ourselves to what we have learned through student surveys and analysis of the software’s metadata to address the first question, and an attempt to quantify whether use of the platform affects long-term retention.

The 3-year project was funded through a Comenius Leadership Fellow Award from the Dutch Research Council for Education Research (NRO). Research performed on student data obtained from Cerego and grades for examinations and retention tests have been performed by ethical standards set by Leiden University and agree with European privacy legislation (GDPR).

3. BRIEF LITERATURE REVIEW

Cerego is an education software company whose main product is a mobile phone-based cation bearing the same name. It is described as an adaptive learning platform that uses artificial intelligence to optimize each student’s learning through spaced repetition and taking advantage of the testing effect (Harlow et al., 2016; Harlow, 2018). To do so, it uses three primary metrics: Knowledge, Diligence, and Agility. These metrics are established from a student interacting repeatedly with the application. In the app, learning content and summative testing are offered, e.g., in the form of short information blocks, PDF formatted MS PowerPoint slides that were also used in lectures, flashcards, ordering assignments, and clickable items. Students are enticed to interact with the learning content through push message technology that relies on a scheduling algorithm. Cerego itself only provides the digital platform and infrastructure for learning. The actual learning content is created by the user, e.g., a professor of a course at a university. Metadata available to the user (i.e., professor) are, a.o., the average course progress for each student within a course and the "progress to goal" per set of learning materials for each student. The course progress quantifies the extent to which a student has reached the retention goal for all available sets. The retention goal, which may vary per set, is a value between 0 and 3.0. It reflects the estimated length of retention and suggests an average period with regular study sessions required to reach the retention goal. For a goal level of 2.0, 2-to-3 weeks of brief reviews spaced increasingly apart are generally needed to obtain retention for weeks to months.

Some prior research has been performed that is based on the same application. In collaboration with UH Manoa and using very simple, foundational macroeconomic content in Cerego, researchers found evidence for improved analytical abilities among those who built retention using Cerego (Harlow et al., 2019). At the New York University College of Dentistry, Cerego was used to provide a self-guided study of anatomy in preparation for the National Board Dental Examination Part I. The authors indicate that the use of Cerego effectively replaced 96 faculty hours of instruction. More interestingly, though, "results for the anatomy portion of the board exam demonstrate student success, with NYU Dentistry students as a whole achieving a 97.1–100% first-time pass rate and performing at 1.4–2.6 standard deviations above the mean for all dental schools in anatomy in the years 2015–2017." (Warshaw et al. 2018). In Turkey, Cerego was applied in an innovative game-based learning intervention for Syrian refugee children a language project. A controlled field experiment showed "significant improvements in Turkish language acquisition, coding, executive functioning and overall sense of hopefulness." (Sirin et al. 2018). In Australia, Cerego was implemented in teaching a 1st-year introductory chemistry course at the Queensland University. Authors find empirical evidence that "supports the benefit adaptive learning has on outcomes, in both the short and long term". The argument is based primarily on a comparison of grades for a 2nd year "Organic Chemistry" course between students that did and did not take the prior introductory course that implemented Cerego.

3. METHODOLOGY

3.1 General Implementation

In 2019, a 3-year 'all you can eat' license was purchased from Cerego, i.e., an unrestricted license for all Leiden University students and staff members. The learning platform was not coupled to Leiden University's learning management system (LMS), i.e., BrightSpace, as it was not clear whether the license was to be continued after the 3-year pilot. Hence, students had to be made aware of the need to create an account with Cerego independently and download the associated application to their mobile phones. Licensed use was verified by the extension of the student's email address. No other GDPR-sensitive personal information from students and staff was required.

In the first year and the early part of the second year of the 3-year project, the author informed students of requirements in class or via a recorded video or written message that was posted in an announcement within Brightspace course materials of the participating classes. From the second year onward, this was achieved only via the latter.

Various educators at different faculties were approached in the first year to participate with optional levels of participation in the project. Some teachers opted to create study content and made this available to students during their class with no other engagement. Others participated in collecting information through student surveys or using the platform's available metadata. In case student information was collected to perform research, the appropriate informed consent forms were used. Access to Cerego content for a course in such cases went via a Qualtrix form that students had to fill out before being registered with Cerego by the educators of a class. In these cases, the university email addresses of students were uploaded to the Cerego course one by one under the oversight of the responsible teacher.

The availability of the new learning platform was advertised at various meetings for teachers on campus, especially between 2019 and 2021. The number of courses in which Cerego content was made available to students increased rapidly. In the 3rd year, teachers at three faculties were using Cerego, i.e., the Faculty of Science (FWN), the Leiden University Medical Center (LUMC), and Archaeology (FA). At FWN, it was used in BSc programs in Biology, Chemistry, Biopharmaceutical Sciences, and Computer Science. It was also used in a single MSc course in the Chemistry department. At the LUMC, Cerego was used in various courses in the medical program, including anatomy and radiology courses. At the FA, it was applied in a BSc course on (ancient) materials. In 2022, over 3000 students at Leiden University registered with Cerego, as determined by counting unique student email addresses known to Cerego.

Data collection methods, instruments, data collection, and analysis as described above, two research questions regarding the implementation of this mobile learning platform had our primary attention. First, we wished to learn from students whether they would adopt a digital tool to help them memorize. Second, we wished to learn whether the use of the platform aided in building long-term retention.

3.1.1 Student surveys

To obtain information that allows us to address the first question, we distributed surveys among students who used the mobile learning platform. Surveys were generally distributed at the end of a course and via the platform itself. Only for Medicine, a survey was distributed via a separate platform. Most surveys contained 4 or 5 statements that were asked to reflect upon using a 1-to-5 Likert scale with "1" indicating complete disagreement and "5" complete agreement. Typical statements were.

1. I liked that Cerego was offered as an extra study resource in [course name].
2. I believe that studying through Cerego helped me in [course name].
3. I would also have liked to have been offered study material via Cerego for the second half of the [course name] course.
4. It would be good if studying with Cerego was offered in more courses of my [program name] program.

Statements in surveys were mostly kept identical between various courses but sometimes varied slightly if aspects of the use of the platform in a course were unique. For example, in the above set of four statements, Cerego content was only offered during the first half of the course, i.e., up to the midterm exam. In other courses, the statement was altered to.

- I would have liked to have been offered more study material via Cerego for [course name].

Results from student surveys were downloaded from Cerego and analyzed further in MS Excel.

3.1.2 Retention test

To obtain information that allows us to address the second question, we picked one course where Cerego would be used in all three years of the pilot and where the course contained two separate examinations, i.e., a midterm and a final exam. The Introductory Chemistry course ("Algemene en Anorganische Chemie", AAC) of the Molecular Science and Technology (MST) program of the Leiden Institute of Chemistry (LIC) was the obvious candidate as the author has taught this course previously and current teachers were willing to participate in research. AAC is offered to students of MST as one of three parallel courses at the start of their BSc program, i.e., in the first quarter of students' first academic year.

In the first year of our 3-year project, study content was developed within Cerego that was also supplied via the course's textbook and/or presented in the MS PowerPoint slides used by AAC teachers for lectures. These were made available to all students before or directly after the lecture through Brightspace. Hence, the Cerego content did not contain any information that was not also provided by the required materials as described in the electronic study guide for students. In addition, there was no significant difference in the availability of the course materials. In this first year, 14 "sets" of learning items (also referred to as "assignments") were designed by the author for AAC in Cerego that allow for memorizing, recognizing, or practicing, e.g., names of chemical structures of complex ions, names and allowable sets of quantum numbers, and shapes of orbitals. Each set is self-contained and focuses on a single (sub)topic from the AAC course contents. Each set contains approximately 10 to 20 items, such as instructions, flashcards, ordering assignments, and clickable images. Each set was made available to students soon after the lecture was presented with the associated topic by the current teachers of AAC. The mastery goal of each set was put to level 2.0 in Cerego. The sets remained accessible to Cerego-registered students until well after the course's final exam. It is important to note that all 14 sets only relate to course content that was discussed up until the midterm examination.

In the third year, the content was expanded to 25 sets by a student assistant who had taken the course the year before, again with the study content also being presented in the textbook and MS PowerPoint files posted on Brightspace. Beyond the midterm, no new Cerego sets (neither on previous nor new study content) were made available. In all three years, students were informed about the availability of Cerego as an additional means to study and practice for AAC. Registration and use of the learning platform were voluntary. The midterm and final examinations of the course were designed by the current teachers of the class without any discussion of the content with the author. The author was informed of the contents of the examinations after they had been taken by students of AAC.

In the second year of the project, a retention test of 30 questions was designed. This retention test was administered in the second and third year of the project at the start of another course of the MST program, which contains to a large extent the same group of students that took AAC five months earlier. This course, called Inorganic Chemistry, is offered in the 4th quarter of the academic year. It is, however, the first and only course in the MST 1st year program that builds on prior chemical knowledge obtained from AAC for which also Cerego content is available. Other courses offered in the 2nd and 3rd quarters do not repeat or build on the knowledge offered in AAC which is also reflected in the Cerego sets.

The 30 retention test items were distributed over two categories. The first contains 21 test items that reflect study content of AAC that was both available through regular means and the learning platform. Answering the remaining 9 test items required knowledge for which no Cerego content was created. Test item types were distributed over multiple answers (3), multiple choice, (17), true/false (8), and ordering (2). True/false questions were overrepresented in the 9 test items that reflected learning content not offered via Cerego (6 out of 9 versus 2 out of 21). A typical multiple-answer test item would contain a question such as "What are the oxidation states of Fe?" with all possible integer values between 1+ and 8+ as options. A typical multiple-choice item would contain a question such as "What is the name of the compound NaIO?" and supply four seemingly logical answers. The same retention test was administered via Brightspace in the 2nd and 3rd years of the project. It was announced to be available immediately at the first lecture of the Inorganic Chemistry course at the start of the 4th quarter. It was indicated to be voluntary and have no other consequence. The test was time-limited to 15 minutes and password-protected so that no one outside of the lecture hall could participate. The order of the 30 test items presented to each student was randomly scrambled. In both years, over 100 MST students, most of whom had taken AAC earlier that year, immediately took the retention test.

The following data were collected:

- from Cerego: all progress scores for each set and each student that had used any set within Cerego during the AAC course. The collected data was time-stamped to the date of the final exam. Hence, additional use of Cerego by students after the course ended is not reflected in the data. We have verified that hardly any student used Cerego after finishing the AAC course.
- from the digital assessment tool used at FWN ("ANS", https://ans.app/landing): the midterm and final exam scores of all AAC students, including partial scores on all individual test items.
- from the LMS Brightspace: the retention test scores of all students including all scores on each of the 30 test items.

Data were assembled in various MS Excel spreadsheets. For each item on the retention test, it was established which of the 14 (later 25) Cerego sets offered during AAC possibly contributed to being able to answer each retention test item. Generally, there was only one set that could contribute to a single test item. For a single retention test item, two Cerego sets reflected learning content. For 9 out of 30 questions, there were no related Cerego sets, as indicated previously. We combined results for each student to be able to connect individual progress on each relevant Cerego set to the performance of the same student on the related retention test item. For these students, we also added midterm and final exam scores if available. Note that not all students took midterm and final exams for AAC and that not all students of AAC were present at the voluntary retention test administered five months afterward. Students for whom not all relevant data was available were filtered out of the data set when addressing the potential learning effects of the platform.

4. RESULTS AND DISCUSSION

4.1 Student surveys

Table 1 supplies information on enrolment, the number of voluntary Cerego users, the number of study sets supplied within Cerego, the fraction of Cerego enrolment reaching more than one-third of the progress goals within Cerego, and the number of respondents for five student surveys administered in the 1st and 2nd years of the project. The class size varies widely as well as the Cerego enrolment. While only 16% of the class enrolment registered to use Cerego for Cell Biology and Biochemistry in the BSc program Life Science and Technology (LST), 81% of the students registered to use Cerego in the Biology program. From those who did register, at least half of the Cerego students put in enough time and effort to reach one-third of the progress goals within Cerego, regardless of the number of sets offered. There does not seem to be any correlation between these variables. The total number of respondents is in all cases rather low, except for Biology where more than half of Cerego users also took the effort to fill out the survey.

Table 1. Information on five student surveys

	Course name	Program	N_E	N_C	sets	>32%	N_S
1	Biochemistry 1	Biopharmaceutical Sciences	487	126	4	50%	22
2	Cell biology and biochemistry	Life Science and Technology	218	34	4	56%	16
3	Introductory Chemistry	Molecular Science and Technology	189	57	13	51%	18
4	Metals and Life	Chemistry	47	24	3		5
5	Developmental Biology	Biology	184	149	20	74%	79

Class enrolment: N_E, Cerego enrolment: N_C, number of Cerego study sets: “sets”, a fraction of Cerego enrolment reaching more than 32% of course progress within Cerego: “>32%”, filled out surveys: N_S.

The results of the survey for the same courses are represented graphically in Figure 2 for four (nearly) identical statements that probe student experience. The first and last questions are somewhat related and indicate that Cerego users enjoyed using the platform and wish it to be used in more courses of their academic program. Especially the last statement scores consistently very high. Students predominantly believe that using Cerego helped them with studying. The statement "wanting more content within Cerego for this course" scores lowest and varies the most. Noting the data in Table 1 on the number of data sets offered in each of these courses, there does not seem to be a relation between the actual amount of study content offered and the wish for more content on the platform.

A similar survey held amongst > 300 medical students in the 2nd year of the project yields the same results: students indicate that they enjoy using the platform, they believe it helped them in their studies, and they wish it to be used in more courses.

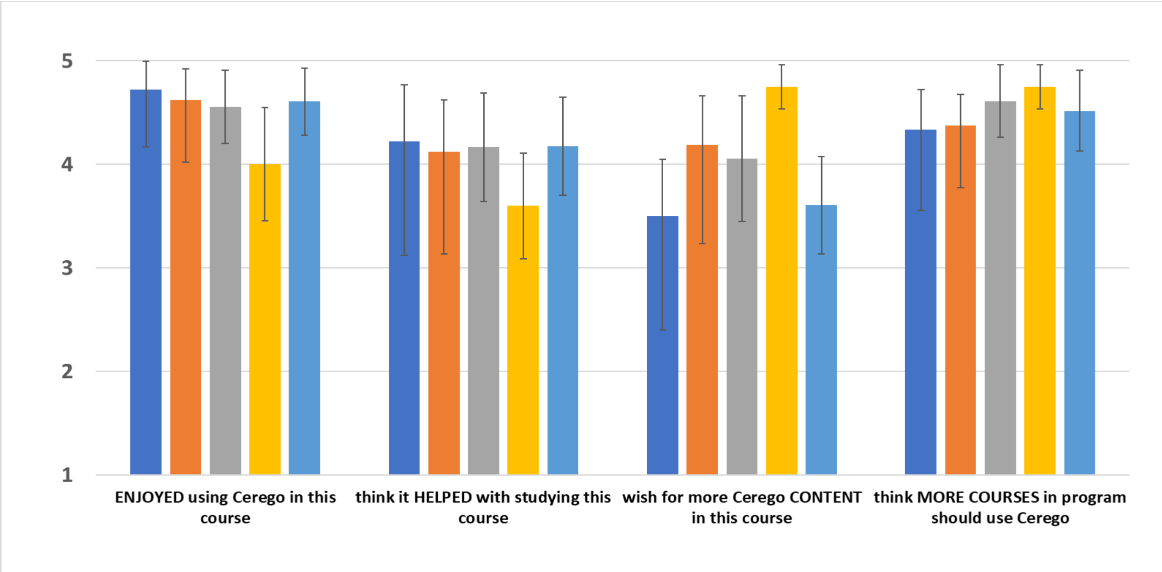

Figure 1 Likert scale agreement scores

Figure 1: "1" indicating full disagreement and "5" full agreement on statements in student surveys for five different courses and programs of the Faculty of Science. Dark blue: Biochemistry 1, Biopharmaceutical Sciences (BSc); Orange: Cell Biology and Biochemistry, Life Science and Technology (BSc); Grey: Introductory Chemistry, Molecular Science and Technology (BSc); Yellow: Metals and Life, Chemistry (MSc); Light blue = Developmental Biology, Biology (BSc). The essence of the survey statement is indicated below the scores.

4.2 Retention test study

4.2.1 Average retention test results

Table 2 supplies information on enrolment in the MST program, the number of students (actively) using Cerego during the AAC course, the number of students taking the retention test (RT) in the 4th quarter, the normalized average grade of all students taking the retention test, and numbers of students that used Cerego (actively) and took the retention test. From the data, an interesting observation is that in the second year (2022) a much larger fraction of students enrolled in the MST program registered to use Cerego for AAC but did not use it at all. We do not have a good explanation for this observation. A second observation is that all other numbers are similar in both years. The fraction of active users, with 'active' being defined as having done any studying on the 14 (25) sets (ranging from 1 to 100%

of the course progress), is in both years nearly 30%. This is low in comparison to other programs, e.g., Biology and Medicine, where over 75% of the students that registered for the course also registered for Cerego. It is, in our opinion, likely that such variations are a consequence of variations in technology acceptance for students of different academic programs. Technology that aims to support the lowest level in Bloom's taxonomy is more likely to find high acceptance in programs where knowledge-by-heart is considered of high value. We expect that this value will be higher for the softer sciences and lower for the harder sciences.

Table 2. Information on retention tests in the 4th quarter of 2021 and 2022

	Course name	Q4 2021	Q4 2022
1	MST freshmen	167	158
2	Cerego registrations [1]	57	135
3	Active Cerego users [2]	48	45
4	Retention test (RT) candidates	118	102
5	Averaged normalized RT score (σ)	0.532 (0.137)	0.537 (0.141)
6	Number of registered Cerego *and* RT candidates [1]	37	70
7	Took retention test *and* active Cerego users [2]	35	43

The number of enrolled freshman students in the MST program (1) and number of registered and active Cerego students from this cohort (2 and 3), number of retention tests finished with the normalized scores (4 and 5), and the number of students who were registered for Cerego and took the retention test (6 and 7).
[1] 'Registered' is defined as the student appearing in the Cerego's registration list for the AAC course, but not necessarily having studied within the platform. [2] 'Active' is defined as showing a course progress > 0%.

Figure 2 graphically illustrates the relation between the normalized retention test scores and the average course progress for a subset of active Cerego users. The average score of all retention test candidates for both years was 0.54 +/- 0.14 in both years, as illustrated by the horizontal black dashed line (see also Table 2). The students who did not register for Cerego scored lower than the overall average, i.e., 0.51 +/- 0.12 and 0.48 +/- 0.15, respectively, in the consecutive years. These are indicated by the horizontal dashed lines (blue for 2021 and red for 2022). Students who used Cerego scored higher on average. There also seems to be a clear relationship between the course progress of these students and their performance on the retention test 5 months later. The reported scores are cumulative averages, with the number of active Cerego users over which is averaged being indicated by the number in between brackets over several of the markers. We find the same trend in both years (blue for 2021 and red for 2022). The increase in performance at the retention test appears mostly linear with the course progress. We only observe a minor deviation at the lowest uses of the platform.

This result suggests that active use of the platform increases retention as the retention test itself mostly captures knowledge and some comprehension and application. The effect also seems significant. The most avid Cerego users score approximately 0.2 points higher than those who did not or hardly used the platform to study on the normalized scale (~0.7 vs. ~0.5). This would be an improvement of roughly 40%.

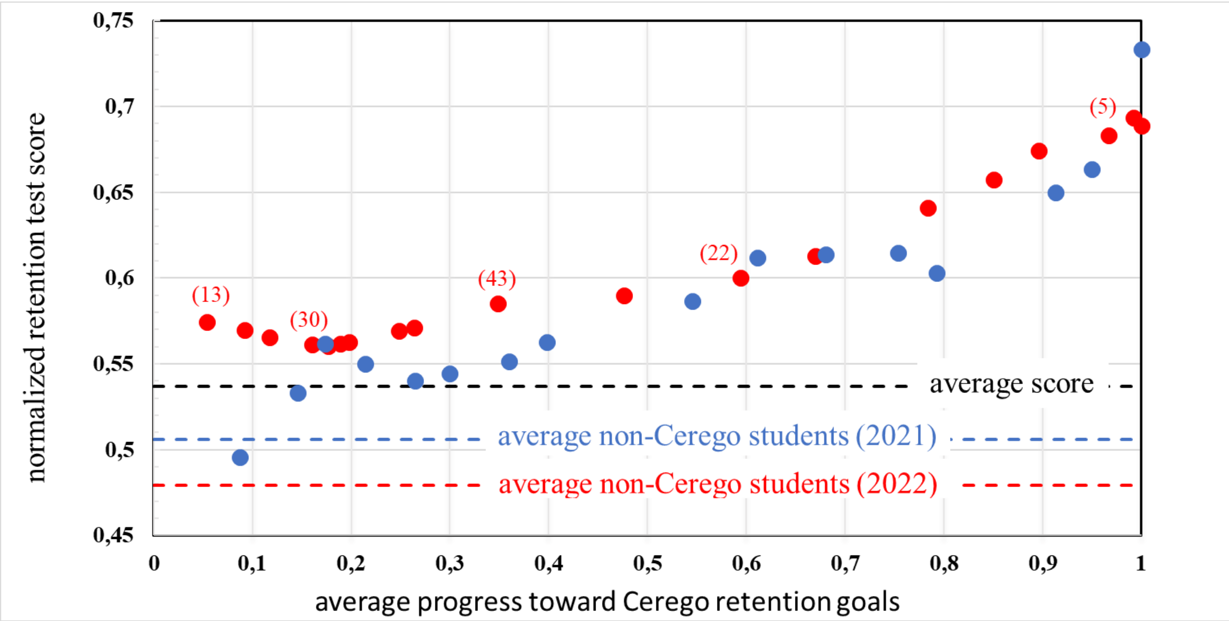

Figure 2 Normalized retention test scores

Normalised retention test scores as a function of the progress toward learning goals as defined within Cerego (retention level 2.0). Also indicated are various averages for subsets of students.

4.2.2 Itemized retention test results

Although the data in Figure 2 suggests a relation between active use of the platform and long-term retention (here being measured after 5 months), we must be careful not to overlook the potential influence of the voluntary character of registration and use of the platform. A volunteer bias is well known, a.o., in clinical studies, where participants have intrinsically different characteristics from the general population (Jordan et al., 2013; Tripepi et al. 2010). We may be selecting a group of students that has a higher intrinsic motivation to study hard and obtain high grades. Their willingness to do so may be reflected in their use of the adaptive learning platform and cause the apparent relationship between the normalized retention test scores and the progress toward Cerego retention goals.

We have taken two independent approaches to unravel better whether the results from Figure 2 can truly be interpreted in terms of a relationship between the use of the platform and actual improved long-term retention. Before applying for these, though, we analyzed the retention test itself and identified better and worse test items. The test scores show a normal distribution, indicating that the standard deviation (σ) is a valid parameter to be used in statistical arguments. We have used the difficulty of all test items as a first measure of validity. Those items that appear either too hard or too simple, as defined by their average score deviating more than two standard deviations from the mean score for all test items, are considered of questionable quality. We have used the discrimination index (DI) as the second measure of the validity of test items. We have put the minimum level of the DI at 0.2. These standards yield nearly the same subset of items that may be considered of questionable quality. We took the combination of both subsets and identified in total 9 questions that may be discarded to improve our comparison of students and their test results. In the following, we regularly do and do not discard these 9 items to show that it makes no difference for qualitative conclusions but does affect quantitative conclusions. Our first approach to unravel a potential selection bias from a true retention effect compares retention test scores for Cerego users (with varying degrees of having used the platform) for the 21 questions that had a clear relation to the 14 (25) offered sets within Cerego to the 9 questions that had no relevant study material within Cerego. We make the same comparison both before and after removing the 9 test items of questionable quality.

Results are graphically illustrated in Figure 3 for the latter case only.

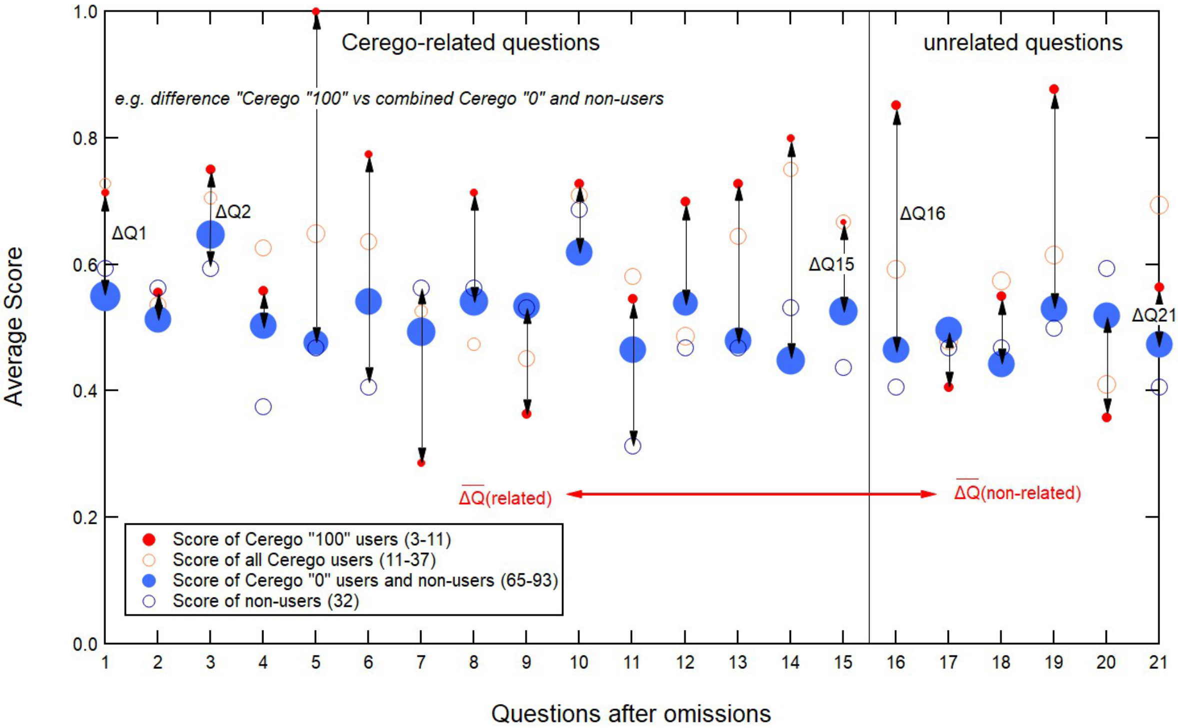

Figure 3 Normalized retention test scores

Data for the 15 remaining questions from 21 that had a relation to offered Cerego content are shown on the left of the vertical division. The 6 out of 9 items remaining after the removal of items of questionable quality and not having any relation to offered Cerego content are shown to the right of the dividing line. The data show the normalized scores for various subsets of students. Blue open symbols represent students who did not register for Cerego at all. Solid blue markers represent all students that did not use Cerego, hence also those that registered for Cerego, but did not study the set that is relevant to answering that question. Open red symbols represent the average score of all Cerego users who studied the relevant set to any progress level. Solid red symbols represent the score for those who studied the relevant set only to the maximum degree (100% of progress toward retention level 2.0). The size of the markers represents (by surface area) the relative sample sizes. Figure 3 indicates scores for various subsets of students separated for 15 items with and 6 items without related Cerego content offered 5 months before.

Qualitatively, students who studied the related set within Cerego for the first 15 test items almost always perform considerably better than any other subset of students. Only for items #7 and #9, this is not the case. They appear exceptions to the opposite group of 13 test items for which it is true. When Cerego users who did not study the related set as well are included in the average score (the open red circles), the differences in the performance as compared to non-Cerego-users (blue open or closed markers) generally diminish. They perform, however, still noticeably better on most test items. This observation confirms the earlier finding that using Cerego appears to improve retention, but now per test item and considering explicitly whether a student spent time studying the related set only. This is a stronger argument for a relationship between the use of the adaptive learning platform and long-term retention but still does not fully dismiss the potential influence of a selection bias.

For the 6 test items that did not have related Cerego sets, i.e., items #16 through #21, the same observations are made, but the differences seem smaller. Now, the “Cerego 100 students” do better on 4 out of 6 questions even though these test items did not have a related Cerego set. This is somewhat troubling as for these test items one may intuitively expect that there should be no difference at all between any of the subgroups. The fact that Cerego users mostly do better on these questions could point toward the earlier-mentioned selection bias.

To define the differences in performance of the various groups more sharply, we quantify them by averaging the differences in scores per item but keeping the separation of items #1 through #15 and items #16- #21. These differences are graphically illustrated in Figure 3 for two subsets of students (the red and blue solid markers) by vertical arrows and indications “ΔQx” (with x being the test item number). We take the ratio of these averages for the items with and without relation to Cerego sets, i.e., $\frac{\overline{\Delta Q}(related)}{\overline{\Delta Q}(\mathbf{un}related)}$. We compare the results in Table 3 for two subgroups of Cerego-users and two subgroups of those who did not study the related subsets. The data shows that the most relevant Cerego users, i.e., those who studied the related set in Cerego to 100% of the retention goal (“Cerego 100”), outperform both subgroups of non-users *more* for the related test items than for the unrelated test items. The ratio is approximately 1.2 (120%). In other words, how much better avid Cerego users do depends on the availability of study content in Cerego. When there is no related Cerego set, they still do better than non-users, but the difference becomes smaller than when there is a related Cerego set for the test item. When including all Cerego users in the analysis (i.e., not only the Cerego 100), even those that may have studied the related set only for 1% of the study goal, the differences become less clear.

Table 3. Comparison of relative performance for subgroups on retention test items with and without relationship to Cerego sets.

$\frac{\overline{\Delta Q}(related)}{\overline{\Delta Q}(\text{un}related)}$	Cerego "0" and non-Cerego users	Non-Cerego users
Cerego 100	118%	121%
all Cerego users	118%	96%

Summarizing the results of this analysis based on the performance of individual test items and groups of test items, we conclude that the data support a relationship between the use of the platform and the construction of long-term retention, but that an inherent selection bias to our experimental design may be exaggerating the effect. While from Figure 1 the test score enhancement was suggested to be up to 40%, it is here only 20% when comparing the most avid Cerego users to non-users. On the other hand, it may also be the case that students who 'kept up' with the class by adequately using the learning platform benefit from a 'compounding effect' (Harlow et al., 2019). Even though there was no Cerego study content offered between the midterm and the final exam, having been better prepared up to the midterm may have a positive effect on learning progression in the second half of the course.

Bypassing a potential selection bias

Our second approach to unraveling a potential selection bias from a true retention effect by the intervention uses the examination results of the AAC final examinations. Recall that the Cerego content offered in this course in 14 (25) sets only relates to the content discussed and tested up until the midterm exam. The final exam was checked in detail and, excepting one test item that was worth 1 out of the total of 100 points for this exam, there was no direct relation between any of the test items and the Cerego sets offered during the course. Hence, the performance on the final exam for AAC cannot be directly influenced by the choice to use or not use Cerego to study for this course. This allows us to create two groups of students that performed (nearly) identically on the final exam and compare their performance on the retention test 5 months later.

In the simplest version of this approach, we matched every 'avid Cerego user' who attained at least 50% of the course progress to a student who did not or hardly used Cerego, but who scored (nearly) identically on the AAC final exam. The optimal comparison is reflected in Table 4. It shows for both sets of students their AAC final exam scores and their course progress within Cerego. For each 'avid Cerego user' (red) the best match (blue) was hand-picked from the AAC grades list. These two groups truly compare well with final AAC exam score averages of 6.43 ($\sigma = 2.10$) and 6.39 ($\sigma = 2.17$). Their comparative performance on the retention test is shown in Figure 4. Red markers identify the 'avid Cerego users. Blue markers are used for the comparison group. The comparison of all 30 retention test items is shown. The 9 test items of questionable quality appear with an additional cross in the marker. Qualitatively it is immediately clear that the avid Cerego users outperform the optimal comparison group on most of the retention test items. The differences are quantified in Table 4. Considering all 30 test items, the avid Cerego users scored 20% better, i.e., they correctly answered 18.3 out of 30 test items whereas the comparison group answered 15.3 items correctly on average. When neglecting items of questionable quality, the improvement diminished but is still substantial.

Table 4. AAC final grades and Cerego were used for two optimal comparison groups of 19 students.

	Grade avid Cerego student	Attained Cerego progress	Grade non(-avid) Cerego student	Attained Cerego progress
1	10	96%	10	24%
2	9,53	98%	9,29	n.a.
3	8,82	99%	8,82	4%
4	8,35	68%	8,24	4%
5	8,35	55%	8,24	0%
6	7,65	55%	7,77	n.a.
7	7,06	60%	7,06	42%
8	6,71	73%	6,71	5%
9	6,12	99%	6,18	n.a.
10	6	52%	6	n.a.
11	5,65	79%	5,71	0%
12	5,65	54%	5,65	n.a.
13	5,59	99%	5,59	24%
14	5,24	51%	5,53	n.a.
15	4,77	53%	4,77	33%
16	4,53	82%	4,47	n.a.
17	4	61%	4,06	n.a.
18	1,77	91%	1	7%

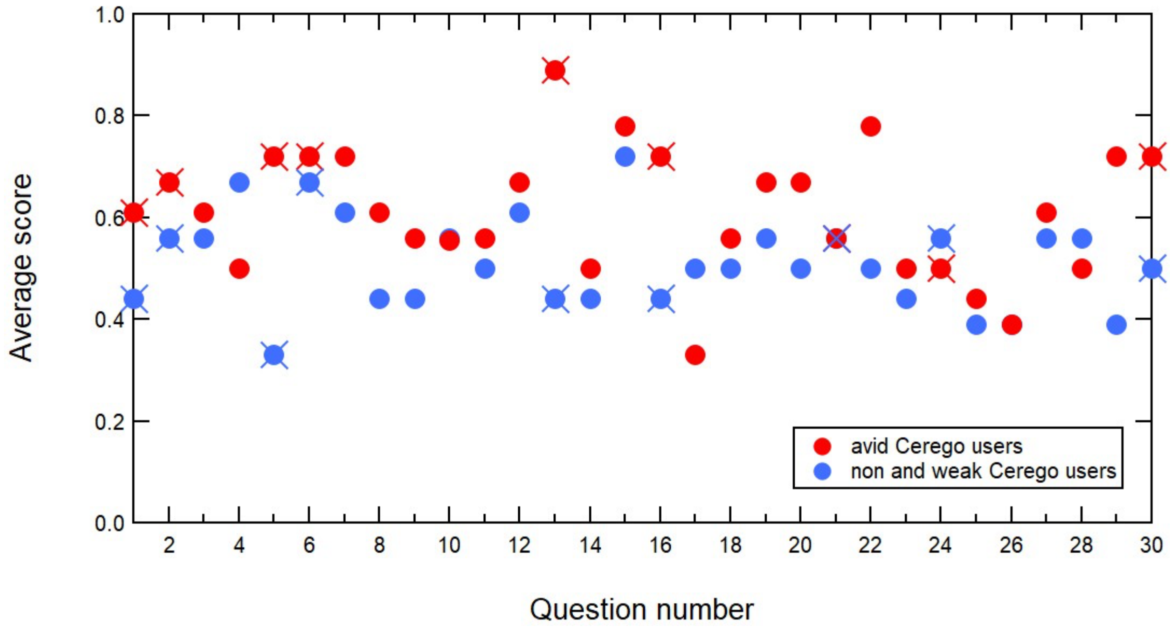

Figure 4 Normalized retention test scores

Figure 4 indicates normalized retention test scores for the two most comparable sets of 18 students as based on AAC final exam scores.

Table 5. Performance on retention test for a group of 18 avid Cerego users to a group of 18 most comparable students

	Average RT score avid Cerego users	Average RT score non/poor Cerego users	Improvement
Complete a set of 30 questions	18.3	15.3	+20%
Partial set of 21 questions	12.2	10.8	+13%

The same analysis was also performed with two variables to allow for creating many more comparison groups. The two variables are.

1. the allowed difference in AAC final exam score for each pair of students (one from the Cerego users' group and one from the remainder). This comparison interval is allowed to take values of 0.25, 0.5, 0.75, and 1 point on the AAC final.
2. the minimum Cerego course progress (the "Cerego cutoff"). This parameter takes on values from 0.1 to 0.9 with 0.1 intervals.

The latter influences the size of the 'avid Cerego users' group. As shown in Table 4, with the cutoff at 50% progress, we limit this group to 18 students. Lowering the cutoff to 0.4 or further increases the size of this group and vice versa. An increase in the former variable allows for 'hand picking' an increasing number of students from the group falling outside of the Cerego cutoff range (the 'non-users').

We automated the comparison and calculated the differences in average retention test performance with a home-developed Python code. The code ensures that students in the comparison group were never used twice in the same iteration. Also, in case no comparable student was found for an avid-Cerego user within the allowed comparison interval (e.g., because the only comparable student from the non-user's group was already used in a different couple), then that avid-Cerego student would be omitted from the iteration. For each combination of the two variables, we thus created 500 comparison groups for each avid-Cerego user group. For each of the 500 comparisons, we calculated the difference in the retention test score and weighted it for the difference in the use of Cerego between the two groups. Taking another look at Table 4, note that some of the students in the comparison group have used Cerego to some extent. With this weighting, we consider that some of the students in the comparison group used Cerego as well. We then averaged this weighted score difference for the 500 groups and moved on to the next combination of the two variables. Results are shown in Figures 5a and 5b. The difference between the two is the treatment of one student, who used Cerego quite extensively but scored a 1.77 on the final exam (see Table 4). As hardly any other student scored this low, there are very few or no options for comparison for this student and in many calculations this student needed to be omitted. For Figure 5b, we artificially inflated this student's AAC final exam score to 2.6, allowing for many more comparisons that include this person's use of Cerego. This is reflected in a small increase in the maximum weighted retention test differences.

We have also varied another aspect, e.g., randomly picking any student from the comparison pool when no comparable student was allowed within the comparison interval. We also examined the combination of both adaptations. All results show the same characteristics though and are already reflected by the surfaces shown in Figures 5a and 5b. There is no significant dependence on the comparison interval, but a clear variation with the Cerego cutoff. The improvement in the retention test score for avid Cerego users markedly increases around a cutoff of 0.5 (50%). When including students that used Cerego to less than 50% of course progress, this group correctly answered between 0 and 0.4 test items more on the retention test than the non-Cerego users. When we define 'avid Cerego users' as having reached at least 50% of the progress toward the retention goal, the difference sharply increases to at least ~1 additional good answer on the retention test. Considering that in this analysis we only used the 21 'good' questions from the retention test and that non-users answered on average 12 of these 21 correctly, the Cerego users group performed roughly 10% better after 5 months on the test.

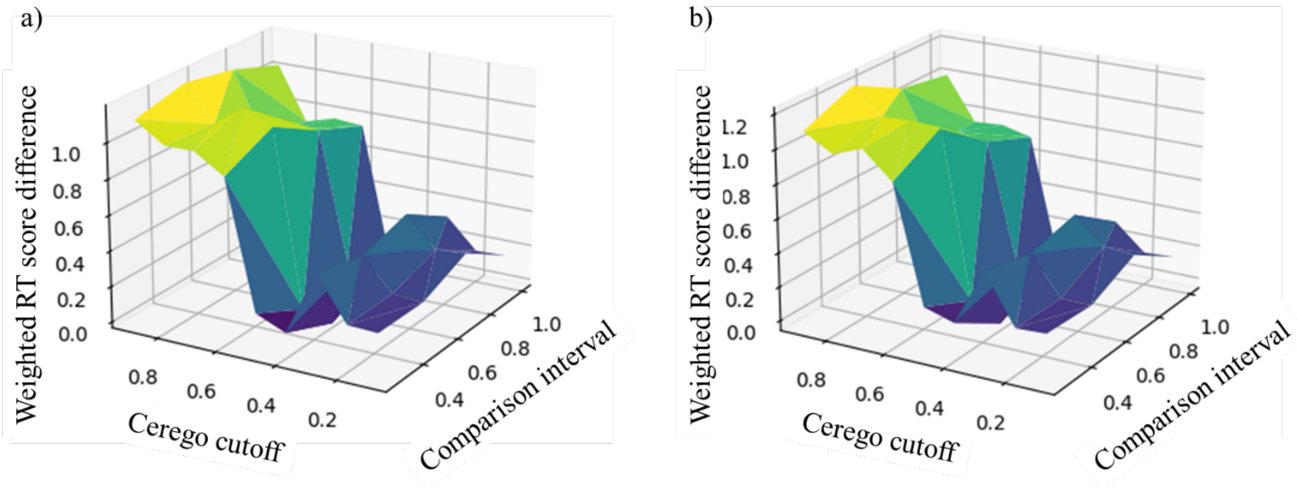

Figure 5 Cerego-use-weighted differences in test scores

Figure 5 indicates the Cerego-use-weighted differences in test scores as a function of the comparison interval and Cerego-cutoff for a) all students with original AAC final scores and b) with one student's AAC final score manually adapted. Each value in the graph represents an average of 500 different comparison groups to a single set of 'avid Cerego users.

5. CONCLUSION

We have implemented and tested an adaptive mobile learning platform called Cerego at Leiden University. Surveys held at Leiden University indicate that students enjoy using this platform and wish it to be implemented in more courses of their academic program. The fraction of students that voluntarily adopt it as a learning tool varies strongly between faculties and programs, though, which answers the first question in our project. In our efforts to detect whether the vendor's claim that Cerego helps to build long-term retention, we consistently find a benefit to having used the platform in a retention test offered well after an introductory course in the chemistry program. The differences are not large. We find that students who used the platform extensively scored up to 40% higher than those who did not use the platform on a retention test. However, the actual difference due to improved long-term retention is more on the order of 10% as part of the difference results for non-perfect testing (poor test items), from a selection bias and/or a compounding effect. It is important to note that the difference seems resilient to various alterations in the formation of comparison groups and that it is detectable after a 5-month period in which students did not take any course that repeated knowledge from the introductory chemistry course. The difference between Cerego users and non-users likely increases when the retention test is offered after a shorter delay. Finally, we note that the most sophisticated comparison of results suggests a non-linear dependence on the use of the platform and the benefit to long-term retention. We find that the benefit markedly increases for students who used the platform at least to the extent that they passed 50% of the course progress toward the retention goals. Hereby, we have answered the final question of our project.

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DESIGNING ASSESSMENTS WITH MOBILE TOURS TO IMPROVE ACADEMIC INTEGRITY.

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ABSTRACT
This paper describes how the assessment strategy for an online course in which students use personal archival content to create place-based mobile tours, makes the assessment task authentic and engaging and addresses the underlying factors that often lead students to cheat. Each student compiles a community archive of personal interest, then feeds their sources into an online mobile tour development platform according to their own curatorial vision to design and develop their collection as a place-based mobile tour which is published on an app and the web. Our action-research concludes that designing a mobile tour as an assessment task is engaging, strengthens their immersion with the study material, builds their digital and online research skills and gives them an opportunity to implement their own ideas for a real audience. Students enjoy the interaction between the old (archives) and the new (mobile tours), become actively engaged and apply their creativity and resourcefulness to very personal interpretations of the assessment task which mitigates against a student using GenAI, copying work and collusion, therefore heightening assessment security and improving academic integrity.

Keywords: place-based mobile tour; academic integrity; authentic assessment; digital archives

1. INTRODUCTION

Academic integrity is the foundation of every aspect of university life and implies a commitment to act with honesty, trustworthiness, fairness, respect, and responsibility in all academic work. When students fail to act with integrity in their studies, academic misconduct may occur (Bretag, 2019). This may include plagiarism, collusion, copied work, work that has involved significant assistance from a third party, contract cheating, use of artificial intelligence (AI) software, paraphrasing tools and more.

Assessment design, however, is an important way to mitigate the risk of academic misconduct and address the causes that encourage students to want to cheat (Sabrina et al., 2022; Sotiradou et al., 2020; Mahabeer & Pirtheepal 2019). There are at least two ways to think about this. One is to consider the **types of assessment** where there is a likelihood of misconduct, the other is to reflect on the **assessment practices** and decisions, e.g., how assessment decisions are administered and supported (Struyven et al., 2005; Bearman et al., 2016).

Archives and the Digital World[1] is an online course delivered through the Moodle LMS at the University of South Australia (UniSA) in which assessment design encourages academic integrity. It includes authentic assessment tasks and processes that pedagogically scaffold students through archival research methods and the design and development of place-based mobile tours to present and share their personalized archival content using the affordances of a mobile device to combine content, multimedia, simple gamification, and GPS technology to provide an interactive and immersive learning experience and stories. It is this pedagogy as described in (Edmonds & Smith, 2017) which focuses on the educational experiences of students who design their own place-based mobile games that is mitigating against students using generic responses to assessment tasks, copying work and collusion.

2. THE CHALLENGES

2.1 Getting university students interested in historical archives.

Bring the old and the new together! Involve students with new digital technologies which can radically change the possibilities of how and what we can learn and present about the past. But why does this matter? Archives (e.g., images, text, audio, or video, which can either be "born digital" or become digitized) are rich sources of content for digital media professionals (Burgmann, 2008). One way to keep developing and making sure that our cultural heritage is healthy and alive is if students are actively engaged in using them. *Archives and the Digital World* gets students searching for, critically examining, and ethically collecting and using archival sources in ways that are exciting and creative, encouraging them to become active custodians of our cultural heritage. Students then get to design, develop, and publish their archival collection in the STQRY app[2] to bring the past alive by presenting and sharing it as a place-based mobile tour.

How can assessment design be authentic and encourage academic integrity?

The assessment tasks in *Archives and the Digital World* build on the university's three existing assessment practices (i.e. assessment is valid, reliable and fair, promotes academic integrity and provides feedback) and the five characteristics considered as the critical elements of **authentic assessment** (i.e. motivates students to become problem solvers, connects learning to real life, stimulates students to think from multiple perspectives, inspires the application of relevant knowledge and skills, encourages higher order thinking) as shown in the university's definition of Authentic Assessment below (Figure 1). The course learning objectives (Figure 2) strengthen the alignment with

[1] https://online.unisa.edu.au/courses/163284
[2] https://stqry.com

these elements, fostering student learning through an authentic and scaffolded assessment process as described by (Ellis et al., 2019), in which students experience the relevance and benefits of completing all the steps themselves.

Figure 1 – UniSA Assessment Design and Authentic Assessment

- CO1. Demonstrate a knowledge of different types of archives and archival institutions across international, national, state and local environments.
- CO2. Develop a broad understanding of theoretical perspectives in relation to digital archiving.
- CO3. Apply a nuanced understanding of how archives are managed, what they reveal (and conceal).
- CO4. Acquire and implement new knowledge about how emerging digital technologies are transforming the archival world.
- CO5. Reflect upon the ethical implications, and social and cultural impacts of combining old materials with new technologies.

Figure 2 – Archives & the Digital World course objectives

Egan (2018) suggests students will be less likely to engage in academic misconduct if the assessment task incorporates personal experiences and ideas and where general or AI-generated information does not meet the specific requirements of the assessment task. Because the mobile tour experiences result from integrating personalized archival content in a design-based task which encourages students to actively engage in the creative design process, fostering critical thinking, problem-solving skills, and real-world application of knowledge they strongly mitigate against a student using generic responses to assessment prompts (Dawson, 2020). Students see the assessment as valuable and purposeful and because the course includes the appropriate pedagogical scaffolding to succeed, they can see the benefit in completing the work themselves.

The Assessment Process

Since 2019 when it was first introduced at the university, *Archives and the Digital World* has used student designed place-based mobile tours in its assessment. The assessment is divided into four main tasks.

Task 1 – Choosing a curatorial theme

Students brainstorm a personal curatorial theme and examine how it could be used in the creative industries by institutions such as galleries, libraries, archives, and museums (known as the GLAM sector). For example, students might create an archival history of their ancestors, a local club or landmark, a location, venue, news or historical event, a means of transport, or a religious organization. Students consider what sort of story they would like to tell, who the audience is for the story, how they would like to tell it, and what kind of archives they might need and why. Students then become history detectives and use the internet to search for relevant online archival collections, for example: official documents, visual files (film, photo or art image), sound files (interviews, voice recordings, music) and material objects (family heirlooms, community artefacts, an honor board, a statue), or a physical location such as the local cricket or football ground. They compile their sources then identify and format them according to a template[3] and write a 300-word report to describe how their chosen artefacts relate to each other and support their curatorial vision/theme for the collection. This is submitted online, and feedback is provided through a marking guide. This component of the assessment contributes 20% to the total mark.

Task 2 – Learning to use STQRY

Students are provided with a personal account to STQRY builder[4] and begin experimenting with how a placed-based mobile tour can be used to display their curatorial vision/theme. To assist them, they view previously published mobile tours developed by both students and staff on the UniSA 'Pedagogy GO' app and critique a published tour to better understand how they function. They post reflections about their experience on a Padlet[5]. Then using practical resources provided in the course website (Figure 3) they learn to use and apply the STQRY mobile tour online development platform appropriately to begin to display their archival collection for a specific audience in readiness for the final assessment.

Figure 3 – UniSA developed STQRY design & development guidelines.

[3] https://guides.library.unisa.edu.au/ld.php?content_id=47235371
[4] https://builder.stqry.com
[5] https://padlet.com

Their DRAFT archival experience is played, continually refined and published as a place-based mobile tour on the UniSA 'Pedagogy GO' app (Figure 4) and on the web-based version of the app.[6] Students have the opportunity to give and receive feedback from their peers on their draft to help them integrate new ideas and improve their archival experience. This is part of the process of learning more about how to combine and experiment with curatorial and digital possibilities. They then identify the primary audience for their archival story. Students submit a 100-word summary of their refined curatorial theme, a 250-word summary of their chosen audience and how the mobile tour will be tailored toward for them. They include screen shots of the introductory pages and 'stops' in their mobile tour. Students are strongly encouraged to use the feedback they receive for this assessment task in refining their archival sources, audience, and curatorial theme for their final assessment submission. This component of the assessment contributes 25% to the total mark.

Figure 4 - UniSA Pedagogy GO app

Task 3 – Writing a summary of their theme and publishing the app

Students write a short summary of their refined curatorial theme, including the community from which their archival sources have been selected and a description of who their chosen audience is and how the mobile tour experience has been tailored for them. They preview their place-based mobile tour to check it is working as expected and add any new ideas introduced since sharing with their peers and/or from discussion with their online tutor. Their tour is then published in the UniSA 'Pedagogy GO' app and the web-based version and is marked using a rubric which includes criteria on the experience, archives used, narrative provided, relevance to the intended audience and citations. This component of the assessment contributes 40% to the total mark.

Task 4 – Reflecting on the process

Each student books a time to 'meet' with their online tutor to reflect on their process of creating their place-based mobile tour with their chosen audience. The students are encouraged to actively reflect on their experience creating an audience appropriate place-based mobile tour to display their archival collection. Feedback is provided through a marking guide by the online tutor. This component of the assessment contributes 15% to the total mark.

3. RESULTS

Evaluation of the course has resulted in a spread of grades skewed toward the right (credits, distinctions, and high distinctions) as Figure 5 below shows for the 2023 enrolment where the class size was 32 students.

[6] https://pedagogy.stqry.app

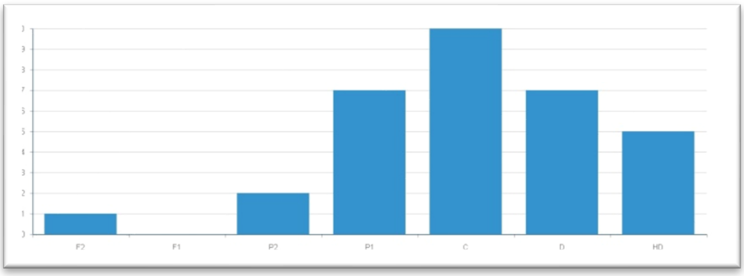

Figure 5 - Assessment Grades for Archives & the Digital World 2023. *[n=32]*

Our action-research included analysing the course evaluation surveys and organizing both informal and formal conversations with students during and after the course. The results of these discussions suggest that many students begin to enjoy the interaction between the old and the new and become actively engaged and interested in the course, particularly when they see its relevance in their program of study, understand early on that academic misconduct is going to be difficult to get away with and strive to produce a personal, long-lasting digital artifact they can be proud of as part of their coursework.

Students have responded positively to this in their course questionnaires.

'It was interesting to learn about location-based mobile archives and make one'.

'The course introduced us to possibilities of different career options within the GLAM sector, which is something I would never have previously considered.'

'A really enjoyable course showing how digital media can be used within the GLAM sector.'

'The amazing teaching staff and the contents, it was amazing to learn about a different side of the digital world then what I am used too.'

'Honestly the course surprised me. Initially while enrolling I was extremely unenthusiastic about this one. The idea of archives bored me, and I didn't know how I would get through the 10 weeks. I am very happy to say that I really enjoyed the course and my whole perception of archives has changed. I really liked the way the assessments were structured too so that we were able to receive feedback and continually improve the quality of the mobile tour.'

Further quantitative research however is required to collect in-depth information from students to verify the reasons for the grade distribution and the course evaluations. This will take the form of surveys and focus groups in 2024.

There is also little doubt that the rich staff/student engagement practices from the professional, skillful, enthusiastic, and creative work of the course facilitator, online tutors and online educational designer contribute to the success of the course. This scaffolding which includes regular Zoom drop-in sessions, videos, multiple eReadings, online forums, course email, interactive elements (H5P), peer-support sessions which together assist students to effectively use time on task, provide opportunities for practice and feedback all strengthening the authenticity of the assessment and lessening the chances of academic misconduct.

4. CONCLUSION

Our action research indicates that students designing place-based mobile learning tours to showcase their personalized digital archives delivers active, engaging, and authentic educational experiences for students that enhance the opportunities for them to interact with locations, mobile content and with each other and which mitigate against breaches of academic integrity. This is supported by the action research of (Edmonds & Smith 2017) in which they described the benefits and deployment strategies of integrating location-based mobile learning games in higher education courses. The assessment design in the course offered students an opportunity to practice varying technical skills and implement their own ideas in a completely new way. This supports one of the key findings of (Slussaref & Boháčková, 2016) who observed a positive effect in students on their acquisition of knowledge in the active (designing) of a location-based mobile learning game. We caution however that these findings should not be generalized due to the small sample size and the current absence of quantitative research to support the action research, but it is hoped that they may widen scholarly discussion about the pedagogical advantages of students designing and developing place-based mobile tours in higher education.

You can view the 2023 students' tours and examples of other mobile tours developed at the University of South Australia by students and staff at https://pedagogy.stqry.app[7] or download the UniSA Pedagogy GO app using the QR Code opposite.

Figure 6 – QR Code Pedagogy GO app.

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[7]https://pedagogy.stqry.app

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USING PHYSICAL COMPUTING TO CROWDSOURCE ENVIRONMENTAL DATA VIA THE INTERNET OF THINGS

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ABSTRACT
Physical computing involves the use of small electronic devices such as single-board computers as learning tools. These devices can be used across many mobile contexts, including environmental monitoring through external sensors. This paper explores a learning design for an activity that uses the micro:bit, a single board computer designed for educational use, to connect a network of sensors and data receivers to create an Internet of Things architecture for environmental monitoring. To provide an authentic context for the learning, the learning design involves the use of environmental sensors to monitor the state of the students' learning environments. The learning activity includes the gathering of data by deploying sensors across different locations and the crowdsourcing of that data with other learners via the Web to support data analysis across different contexts. From a pedagogical perspective, these mobile learning activities provide an opportunity for situated cognition using tools, collaboration, and a cognitive apprenticeship process, which provides the sequencing of the learning design from situated activity to generality. The TPACK framework is used to integrate the technology component into the pedagogical scaffolding.

Keywords: physical computing; micro:bit; Internet of Things; situated cognition; TPACK; crowdsourcing.

1. INTRODUCTION

Physical computing involves the use of portable single-board computers such as the micro:bit, Arduino and Raspberry Pi as learning tools. A single-board computer (SBC) is a complete computer system built on a single, small circuit board, containing the essential components of a computer - processor, memory, storage, and input/output channels. Being small and light, they are highly portable and can be embedded in larger systems. Depending on how they are applied, they can be useful components in mobile learning scenarios. This is a technical/theoretical paper that describes a learning design for a physical computing environment. It outlines the intended learning outcomes and how they are met in a learning activity that explores a process of crowdsourcing environmental data gathered from the students' learning environments using small Internet of Things (IoT) networks. It describes the technology required and how it can be used at each stage of the learning design. This includes micro:bits and external sensors, example code for each step of the process, and a dedicated web app that has been created to enable students to crowdsource and visualise data. Examples of the technology in use are included in this article to illustrate some of the activities in the learning design.

The article is structured as follows. The remainder of this introduction provides more detail about single-board computers, micro:bits, and using IoT and crowdsourcing in a learning environment. The next section describes the learning design using the TPACK framework, using situated cognition as the pedagogical component. The three main stages of the learning process are then illustrated using the process of cognitive apprenticeship to scaffold the learning. This is followed by some conclusions and a discussion of limitations and future work.

1.1 Single Board Computers

Single Board Computers (SBCs) can be coded in various ways to be usable across many mobile contexts. For example, they can be used as stand-alone devices to create simple digital tools such as step counters or compasses. In addition, they can be connected either physically or wirelessly to other devices, for example, they can be used as remote Bluetooth controllers or participate in publish-subscribe radio networks and be connected to a range of different types of sensors. Gathering atmospheric data that can be crowdsourced for analysis is one example of the value of such sensors (Budde, 2021). The combination of communication channels and sensors provides students with many opportunities for scientific discovery and related mathematical skills. For example, SBCs have proved effective in a range of project-based learning activities in the secondary classroom (Steinmeyer, 2015).

1.2 The micro:bit

The micro:bit is a popular SBC, being both affordable and specifically designed for educational use. It provides an LED display, input buttons, radio and Bluetooth connections, USB and battery sockets, and some onboard sensors: light, temperature, direction (compass), acceleration and, from version 2, touch, and sound. The onboard sensors are a key component of the micro:bit's design. The intention was to enable learners to engage creatively with the device and explore a world where sensor-based devices are ubiquitous (Knowles et al., 2018). In addition, a range of external sensors can be connected to a micro:bit using various combinations of external connections (pins) on the edge connector of the board. The micro:bit is prevalent in many classrooms, particularly in the UK, where a million middle school students were given one in 2016 (Ball et al., 2016). A similar exercise took place in 2023 when class sets of 30 version 2 micro:bits were offered to all UK primary schools (BBC, n.d.).

1.3 Learning with the Internet of Things

Integrating the Internet of Things (IoT) into education is a topic that has been previously explored from a range of perspectives. Many examples focus on the technical aspects of IoT networks, but they have also been used across other subject areas, including science, languages, physical education, and business (Kassab et al., 2019). The benefits of learning in an IoT environment have been claimed to include raising awareness about sustainability and ethics (Zeinab et al., 2022), but perhaps the broadest motivation is to expose students to ubiquitous devices that can be of benefit to everyone (Richards &

Woodthorpe, 2009).

micro: bits were designed from the beginning as a means of learning about the Internet of Things (IoT) but since they do not have on-board Internet connections, other components are needed to enable them to become true IoT components, for example by connecting Wi-Fi expansion boards or linking them with internet-enabled devices such as Raspberry Pis or laptop/desktop computers.

1.4 Mobile Crowdsourcing

Crowdsourcing has previously been used for learning about IoT (Hussein et al., 2019), but the learning design in this article is focused on learning through crowdsourcing using IoT as a platform. Further, this activity is based on mobile crowdsourcing. The main characteristics of mobile crowdsourcing are the mobility of devices and their carriers, collaboration through distribution of tasks to achieve a global objective, and human capacity, where individuals are data consumers and producers, and their capabilities enhance the performance of the overall system (Kong et al., 2019). The mobile aspect is important in this learning design because of the element of physical computing in the intended learning experience.

2. THE LEARNING DESIGN AND TPACK

The introduction to this article has described the single board computer as a device suitable for learning, the micro:bit as an educational SBC, and the Internet of Things as a platform to support the mobile crowdsourcing of data gathered from sensors. The learning activity design outlined in this section integrates micro:bits, the IoT, sensor data and crowdsourcing in ways that enhance student learning beyond just the technical content of electronics and coding. At the end of this learning activity, the learner should be able to:

1. Explain the impact of environmental factors on learning spaces,
2. Implement a system of mobile sensors that can gather data from the environment,
3. Demonstrate an understanding of the meaning of data gathered and the parameters of data gathering,
4. Analyse environmental data to draw conclusions about the impacts and mitigations of environmental factors.

To ensure that the activity design has an appropriate pedagogy, the concept of cognitive apprenticeship, from situated cognition theory, has been used to scaffold the learning process (Brown et al., 1989), while the TPACK framework has been applied to integrate the technology with the content and pedagogy (Koehler et al., 2012). This is described in detail in the remainder of this section. This learning design has been developed from a previous series of workshops that prototyped the first two stages of the activity and established some design principles (Parsons & MacCallum, 2022).

2.1 Applying TPACK

Although there are many ways of applying a framework such as TPACK (Technological Pedagogical

Content Knowledge), assessing its impact on practice relies on observation of performance and assessment (Koehler et al., 2012). In addition, the complexity of TPACK (with its seven knowledge constructs) and its emphasis on the technology part of the Pedagogy / Content / Technology triad, means that applying it effectively of necessity means focusing on the PCK (Pedagogy Content Knowledge) supported by the technology (Brantley-Dias & Ertmer, 2014). This is challenging in a situation where technology is a significant component of the learning environment. Previous research into teacher practice when using micro:bits for learning suggests that demonstrations, collaborative work and guided discovery are widely seen as relevant approaches to learning through physical computing. However, teachers are often not able to fully meet their intentions when working with these devices and do not always deliver learning activities that take full advantage of tactile feedback experiences (Kalelioglu & Sentance, 2020). Learning with single-board computers, such as the micro:bit, often focuses on the technology, but lacks a coherent educational approach (Ariza & Baez, 2022).

The learning design outlined in this paper attempts to address these shortcomings by providing a more structured theoretical basis for the learning process. The use of technology is driven by content that is authentic within the students' own learning environment, and the pedagogy is based on cognitive apprenticeship, where the role of the technology is to represent generalised concepts of the learning content and the learning activities with that technology follow the apprenticeship pathway.

2.2 The Content Knowledge in the Learning Design

In the learning design, the content is based on issues related to the physical classroom environment, which have been brought to the fore in recent discussions about the safety of students at school during the COVID-19 pandemic. For example, ventilation levels can be measured by monitoring CO2 concentrations, which can also have a direct impact on student well-being, as do a range of other environmental factors. This learning design aims to give students an opportunity to learn about their own environments while gaining a deeper understanding of the importance of environmental factors for their own well-being.

Many previous studies have explored the impact of different environmental factors in the classroom. These have included lighting, temperature, and humidity (Runathong et al., 2017; Lakshaga Jyothi & Shanmugasundaram, 2021). Several studies have monitored levels of CO2 in classrooms and their potential impacts (Shendell et al., 2004; Gaihre et al., 2014). To successfully use environmental sensors as part of the learning process students must gain a proper understanding of what the sensor data means and how it is used. They need to be able to understand how code and components work together as a feedback system to produce the desired outcomes (Cederqvist, 2022). In addition to this theoretical and technical content, students should be able to gather their own data, share it, analyse it, consider its implications and mitigations, and thereby contribute to their own content knowledge.

2.3 The Pedagogical Knowledge in the Learning Design

Cognitive apprenticeship, as embodied in the theory of situated cognition, structures the progress of learners from embedded activities to general principles (Brown et al., 1989). This sequence begins with apprenticeship and coaching, where educators provide modelling and scaffolding for students to get started in authentic activities. This is followed by a more autonomous phase of collaborative learning, with learners experiencing multiple roles and practices, which leads to them articulating and reflecting on strategies. From this situated understanding, the students' conceptual knowledge can be generalised and further developed (Figure 1).

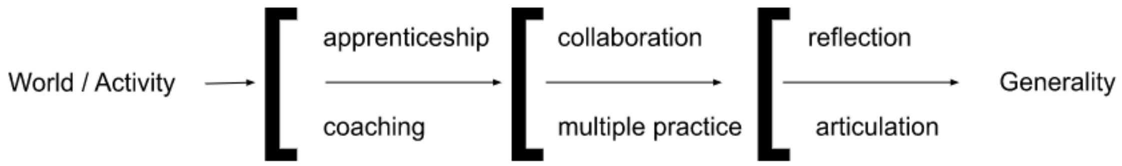

Figure 1. The process of cognitive apprenticeship (adapted from Brown et al., 1989)

These three apprenticeship stages in the pedagogy map to the development steps in content and technological knowledge. First, students gain an understanding of the impacts of various environmental factors in their own learning spaces, and technical content knowledge about how to use micro:bits and sensors to gather environmental data. Then, collaboratively, they gain knowledge from multiple perspectives by exploring their repertoire of data-gathering tools and gain a deeper understanding of this data through reflection. Finally, through a crowdsourcing process they can reflect on multiple sources of data and articulate possible solutions to environmental problems.

2.4 The Technological Knowledge in the Learning Design

To access the content knowledge in the learning process, students need to develop technical knowledge about the hardware and software that is used during the learning. In this case, the hardware is the micro:bit and a range of external sensors, and the software comprises the Microsoft MakeCode Editor and a PHP-based web application. In summary, during the learning activity, students will develop technological knowledge of coding the micro:bit, using its internal sensors, connecting external sensors and gathering data from them, sending data via radio between micro:bits, sending serial data from a micro:bit to the MakeCode editor via USB, monitoring and saving sensor data, uploading it to a server and accessing multiple crowdsourced files and visualisations using a web app.

3. THE STEPS IN THE LEARNING ACTIVITY

The learning activity is divided into three steps, each of which is based on one stage of the cognitive apprenticeship. Each step relates to a pair of features of the apprenticeship process. In this section, the content, pedagogy, and technology that relate to these steps are described.

3.1 Step 1

Content: Using sensors to measure the environment. Foundational content knowledge about environmental factors and their impacts is provided, along with applied knowledge of using the hardware and software.

Pedagogy: The first phase of cognitive apprenticeship is based on coaching, where in situ modelling and scaffolding are provided for students to get started in an authentic activity, and apprenticeship, where learning is embedded in authentic activities that make deliberate use of the social and physical context. These are embodied in this step of the learning activity as follows:

- Coaching - scaffolded instructions and explanations are given, and the technology is demonstrated.
- Apprenticeship - Students code their own devices and use them to explore their environment, making links between data and context.

***Technology*:** micro:bits and coding in the MakeCode editor.

Figure 2 shows the technology components used for this step in the cognitive apprenticeship learning process. While connected to the MakeCode editor on a computer, micro:bits are coded by the students to receive data directly from their own internal sensors. They can then experience mobile data gathering by disconnecting the micro:bits and using them in different parts of the environment to measure factors such as sound, light, and temperature.

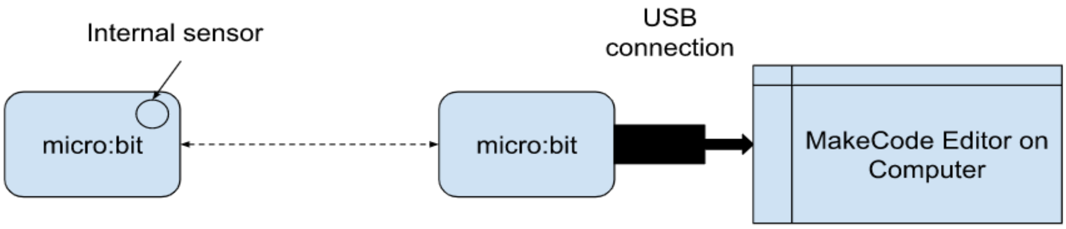

Figure 2. The technology engaged in the first learning step - micro:bits and their internal sensors

3.2 Step 2

Content: Gathering and visualising data from environmental sensors. Students learn about different types of environmental measures and their meanings. They extend their technical knowledge and skills, learning how to remotely capture a stream of sensor data, while critically thinking about solving problems collaboratively.

Pedagogy: The second phase of cognitive apprenticeship is based on collaboration and multiple practice. When collaborating, students engage in collective problem-solving, understanding the many different roles needed for a task, confronting ineffective strategies and misconceptions, and gaining collaborative work skills. In multiple practice, students can compare multiple performances, leading to mastery learning. These are embodied in this step of the learning activity as follows:

- Collaboration: Students are given group challenges with additional technical layers, needing to problem-solve independently
- Multiple practice - students revisit their devices and code and use them in enhanced ways, further developing their skills.

***Technology**:* micro:bits and external sensors forming a small IoT network, data gathering and visualisation in the MakeCode editor, and exporting data to files for analysis. Figure 3 shows the technology components used for this second step in the cognitive apprenticeship learning process.

A micro:bit network is set up where multiple micro:bits receive sensor data (either directly through their own sensors or via serial input from external sensors), and then broadcast that data over a radio channel to a micro:bit that is connected to a computer via USB. Data sent from the receiving micro:bit to the computer can be captured locally from the MakeCode editor either as a CSV file or a text file.

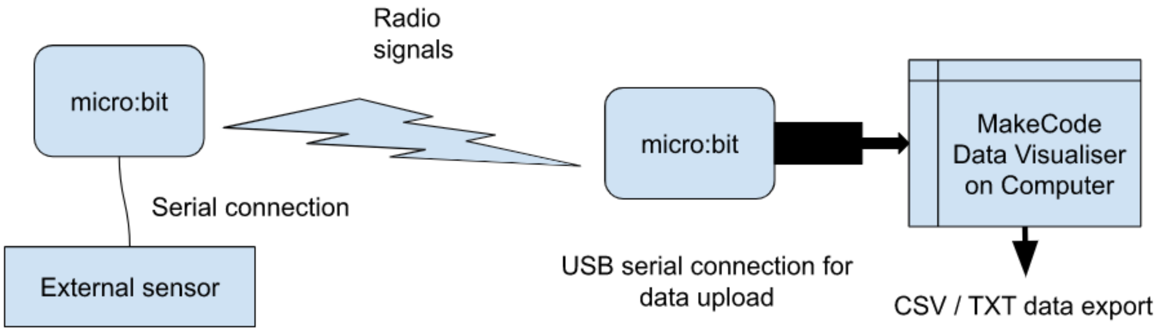

Figure 3. The technology engaged in the second learning step - an IoT architecture of micro:bits with external sensors

The test environment used for developing this step included a range of external sensors, including light, sound, temperature, pressure, humidity, and CO2. For most of these measures, there is more than one sensor available so students can compare values for consistency. The external sensor boards used in the test environment are shown in Table 1. Each sensor board can measure more than one environmental variable. Several boards have MakeCode extensions that make coding easier for learners to program them for use in their own environments. It is worth noting that sensors for sound and light return values that are on arbitrary scales and are therefore only relative, for example, sound sensors are just noise sensors that can, for example, respond to a clap. In contrast, sensors for CO2, temperature, humidity, and pressure all return values that relate to standard measures and can therefore be compared across different devices.

Table 1. External sensors used with the micro:bit

Sensor Board	Sensors	MakeCode Extension	Notes
MonkMakes COZIR sensor	C02, temperature, humidity	Yes	Has its own power supply
MonkMakes air quality sensor	C02, temperature	No	The temperature sensor is used to support the C02 sensor but can also be used separately
MonkMakes sensor board	Temperature, light, sound	Yes	Light and sound levels are measured between 0 and 100
Pimoroni enviro:bit	Temperature, pressure, humidity light (including red, green, and blue levels), sound	Yes	The micro:bit plugs directly into the board. Light level is measured between 0 and 255 and sound level between 0 and +-344

Figure 4 shows an example of micro:bit sensor data being gathered in the MakeCode editor. In this case, a temperature sensor is being used to gather data, which is sent as a serial data stream over a USB connection to the editor. As can be seen in Figure 4, the editor displays the data as text and as a visualisation. However, these representations are ephemeral, so to be able to make further use of the data it needs to be saved to a file so it can be processed elsewhere. The buttons on the right side of the screen allow the data to be downloaded either as a text or CSV file (a comma-separated file that can be read by spreadsheet software such as Microsoft Excel and Google Sheets). In Step 3 of the learning design, students take CSV files created in this way and share them in a web application designed for this activity.

Figure 4. micro:bit sensor data being gathered in the MakeCode editor

3.3 Step 3

Content: Mobile crowdsourcing and analysing data from environmental sensors. Students learn about how to best collect data and apply metadata, share, and analyse large data sets, interpret visualisations, and potentially draw conclusions about how to manage the classroom environment.

Pedagogy: The third phase of cognitive apprenticeship is based on articulation, where students articulate strategies so they can be discussed and reflected upon, and reflection, where students reflect upon, evaluate, and validate the collaborative activities and the performances and roles within them. These are embodied in this step of the learning activity as follows:

- Articulation: Students collectively articulate their strategies for data gathering, sharing, and analysis.
- Reflection: Students reflect upon what happened during their collaborative activities and the outcomes. They consider future actions resulting from their learning.

Technology: web-based crowdsourcing and collaborative data analysis.

Figure 5 shows the technology components used for this final step in the cognitive apprenticeship learning process. Data captured in the previous step can be shared as CSV files using a dedicated web app. This app supports the crowdsourcing of data from multiple locations. Students can then access this data to visualise it or download it to perform their own analyses.

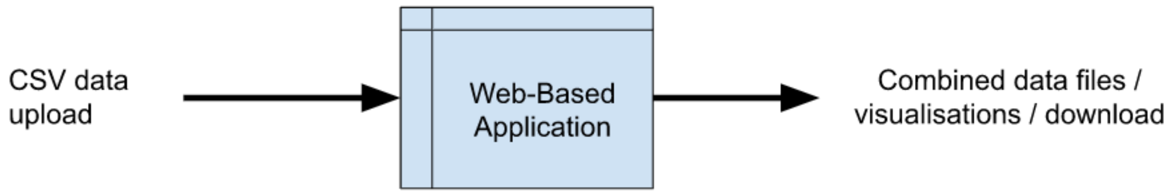

Figure 5. The technology engaged in the third learning step - crowdsourcing data.

Figure 6 shows the upload page of the Web application. Students can upload their CSV files to the server and add some metadata about where and when their measures were taken, and what environmental variable the measures relate to.

Figure 5. The upload page of the web application where students can share their data.

Once files have been uploaded, they can be viewed, downloaded, or visualised by anyone as a crowdsourced data set. Figure 6 shows the page that lists the available data files. Clicking on a filename will download a file and clicking on 'View Graph' will generate a line graph from that file's data.

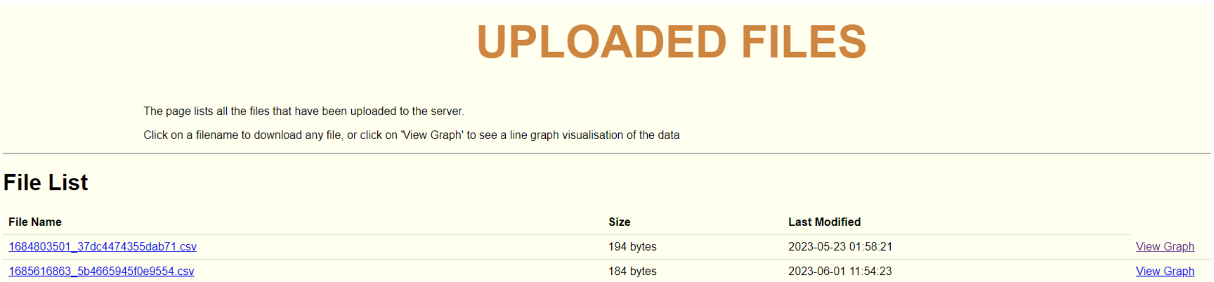

Figure 6. The file list page where students can download or visualise files.

As an example of the type of web-based visualisation possible in the activity, Figure 7 shows a short temperature trace gathered from an external micro:bit sensor over a period of 90 seconds, with measures taken at 5-second intervals, displayed using the 'View Graph' option on the web app page that aggregates multiple data sets.

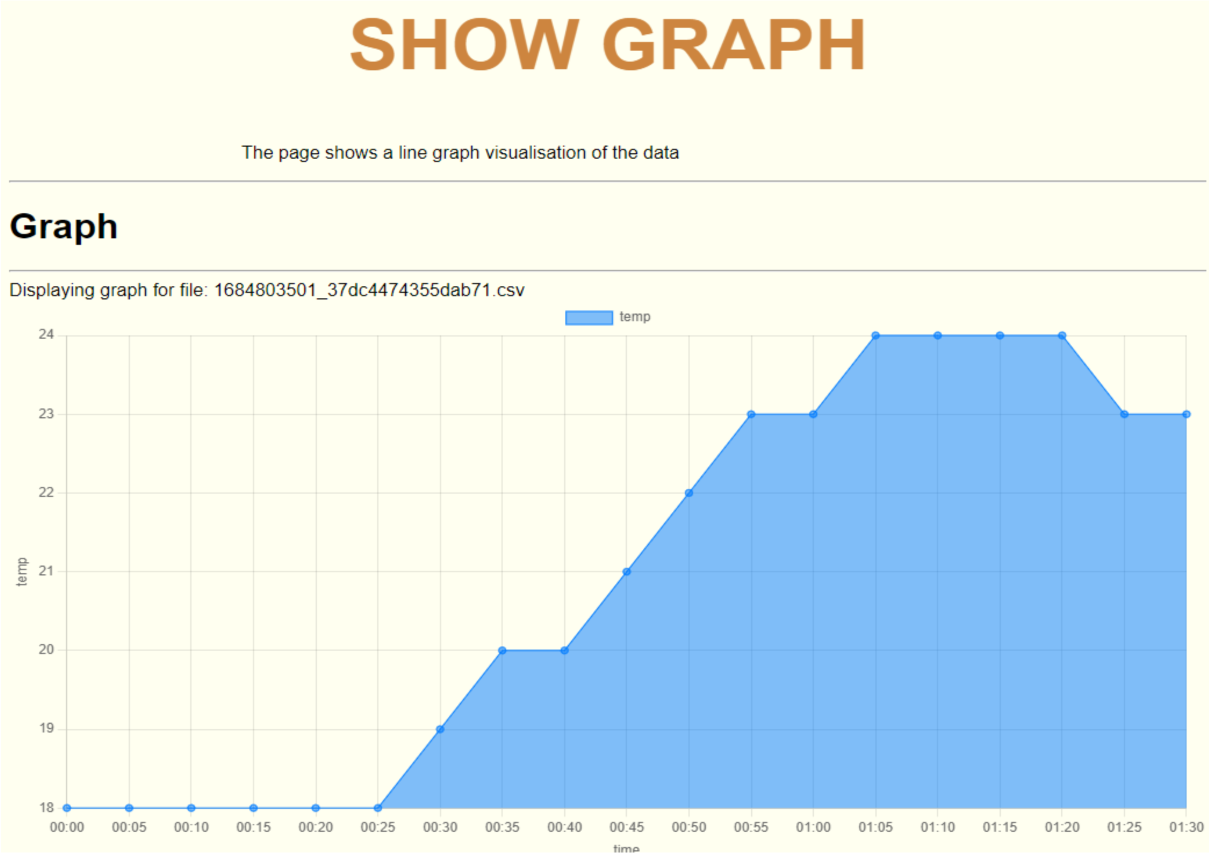

Figure 7. An example visualisation of micro:bit sensor data uploaded to a web app.

4. SUMMARY AND CONCLUSIONS

This article has presented a learning activity design based on students exploring the potential of using physical computing in the classroom, with a particular focus on investigating environmental factors that can be monitored by sensors connected to single-board computers (the micro:bit in this case). The design of the activity was structured within the TPACK framework and grounded in the process of cognitive apprenticeship. Taking the process of cognitive apprenticeship as outlined in Figure 1 and overlaying the activities from the three steps outlined in the previous section, the mapping of the learning design to the underlying cognitive apprenticeship process is shown in Figure 8.

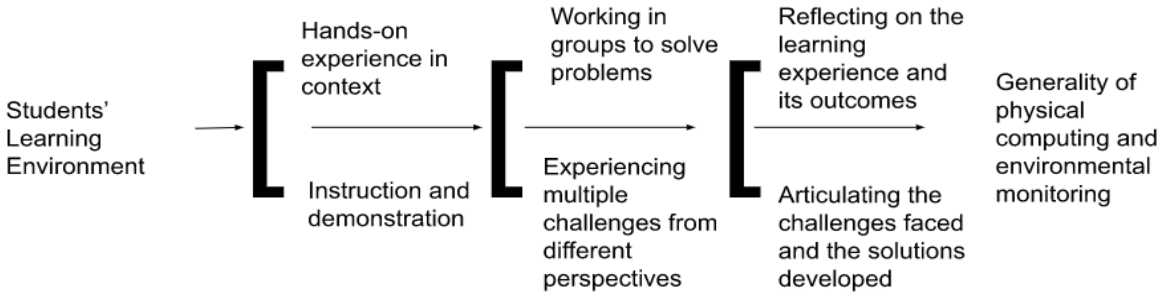

Figure 8. The process of cognitive apprenticeship as embodied in the learning design

This learning activity maps closely to Kong et al's (2019) definition of mobile crowdsourcing because of the mobility of the sensors, the collaborative component of the pedagogy, and the learning tasks of producing and consuming data. Mobile crowdsourcing can have a range of different characteristics (Kong et al., 2019) that can be identified in the final step of the learning activity. It is participatory (data and metadata is submitted consciously), both audience-driven (participants are at the centre) and location-driven (focusing on a particular place), involves both sensing and analytical tasks, and contributions are homogeneous (combined and equally weighted).

Learning activities such as the one described in this paper can provide students with an opportunity to use small mobile, electronic devices for real-world learning with opportunities to develop skills in digital technologies, data analysis, and real-world problem-solving. By taking account of the need to balance technology, pedagogy, and content within the TPACK framework, and applying a suitable pedagogy based on situated cognition, the design seeks to ensure that the technology content does not dominate the learning.

4.1 Limitations and Future Work

The work reported in this article is only design-based and has not been empirically validated. However, it was informed by previous research in a similar area and builds on the outcomes from that work. It is therefore the next step in an ongoing effort to explore the potential of physical computing in mobile learning. As a technical study that can inform ways in which to design physical computing experiences in a specific domain of knowledge, it provides some insights into designing the learner experience that will be valuable going forward. The web application that has been developed to support the activity is also rudimentary at this stage and would need more development to be suitable for deployment on a public server for use by large numbers of students but is sufficient for small workshop use.

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AI: DISRUPTOR OR CATALYST FOR RETHINKING ASSESSMENT?

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ABSTRACT
This conceptual paper explores the similarities of the panic and perceived threats to the reliability, validity, and integrity of assessment during the rapid move to emergency remote teaching (ERT) and online assessment during the Covid-19 pandemic, and the current concerns about the new 'threats' posed by Generative Artificial Intelligence (GEN-AI) to assessment. The paper traces the responses to the challenge to assessment and how we can harness what we learned from online assessment by adapting assessment design and moving away from standard assessment paradigm to safeguard integrity and support student learning. This is underpinned by aligning assessment design with a view to fostering knowledge construction rather than knowledge transfer. This paper presents a structured literature review and reflection on how assessment design was adapted during the pandemic and could be further adapted in the light of AI. Standard assessment paradigms are susceptible to cheating and have been well-critiqued in the literature. A shift from these standard assessment designs is required to foster student learning and to redefine what reliability and validity would mean in the time of AI. The paper argues that the panic and knee-jerk responses to AI's threat to assessment may be appropriate under the conditions of standard assessment practice. If assessment remains focussed on the artifact, which inadvertently favours recall and memory, such as using essays and multiple-choice questions, then AI will prevail. When alternative forms of assessment with diverse assessment types in a course's assessment design are coupled with a clear focus on knowledge construction in the discipline, assessment could be, by design, secured from AI's threat to integrity. In this case, the technology could be harnessed to support teaching, learning and assessment.

Keywords: AI, assessment design; standard assessment paradigm; alternative assessment; knowledge construction; validity; reliability

1. INTRODUCTION

The development of Generative Artificial Intelligence (Gen-AI) has been a hot topic of conversation in education, specifically ChatGPT. The release of this disruptive technology has, for the most part, divided higher education into a spectrum ranging from those who are strong proponents of the new technology and those who are vociferously against it. One thing that many agree on, regardless of where they lie on the spectrum, is that Gen-AI will change the way we teach and assess. Gen-AI is a disruptor that precipitates in higher education institutions a moment in which deep questions about assessment need to be asked: What is the purpose of assessment, and how do we best achieve that end? These kinds of questions need to be debated at various levels if we are to adapt to the new world. In this paper, we put forward a way to understand our current experience by comparing the new with the familiar. We do this by examining the similarities the time of AI shares with teaching online during the pandemic. We start by unpacking what assessment is and how it has been conceptualised and researched. Then, we provide broad brush strokes analysis on the experiences during online teaching and assessment based on a literature review. Finally, we compare this with the current literature on Gen-AI and its influence on assessment.

2. WHAT DO WE MEAN BY ASSESSMENT?

Assessment has a rich history dating back to the Han Dynasty (O'Sullivan & Cheng, 2022). It is an activity all students engaged in any formal education, from primary to higher education, would know well. The standard assessment paradigm, in assessment of learning, is the production of an artifact (essay, exam script, lab report, etc.) that is then judged by one deemed more expert in the knowledge domain (Swiecki et al., 2022). Assessment tasks include high-stakes tests and exams, completing assignments and tutorials or laboratory work in exchange for marks and, ideally, feedback. Assessment in higher education institutions has remained relatively static for a long time. Many of the tasks completed by students who attended higher education institutions between 1950 and the current time are remarkably similar. The literature on assessment shows that there are slight differences between what is valued in different countries and types of institutions, but essentially, it shows remarkable consistency across both time and culture (Bearman et al., 2020). The principle of assessment of learning remains largely unquestioned by both academics and students, and little thought is given to whether assessment in its current form promotes learning (Macdonald & Joughin, 2009).

Over the last twenty years or so, the higher education literature has begun to question the purpose and value of assessment in higher education. Much of this research focused on the traditional or standard assessment paradigm to different ends. This includes the study of assessment to improve the measurement of learning by asking better questions or designing better assessments to measure learning more accurately (Mislevy et al., 2003). Others have argued that assessment drives learning and, as such, assessment should be aligned with the course outcomes (Biggs, 2003).

In this paper, we look at assessment of learning in its broadest form to include as many assessment tasks as possible. Broadly, assessment in this paper is understood as measuring and making judgements about a student's performance by demonstration or a product. This judgement is made by a lecturer, a peer, another student, or someone else. Students then receive a mark or a grade and some feedback to close the assessment loop (Dawson et al., 2020). This form of standard assessment usually includes products such as multiple-choice tests, short answers, and essays, which aim to measure student performance in an objective way to make inferences about the knowledge students have acquired (Kaipa, 2020). What has made standard assessment paradigms so appealing to institutions lies in the 'quality assurance' afforded by the standardised nature of this assessment. This consistency of the product is presumed to provide high reliability in measuring the extent to which all students have mastered the material covered in the course (Boud, 2017). Traditional assessment has a high validity as they test the intended outcomes of programmes and can be measured against others. Lastly, traditional assessment has a high level of integrity in that students are completing their own work as much of this assessment is conducted in invigilated face-to-face settings with invigilators able to restrict, at least in theory, access to class notes or collusion with peers (Bearman et al., 2022; Dawson, 2020; Eaton, 2020).

The standard assessment paradigm has been researched extensively and critiqued in various studies. Swiecki et al. (2022) provides five points of critique of traditional assessment. Firstly, standard assessments are laborious to design and implement and require time and resources to invigilate. Secondly, these traditional assessments tend to provide snapshots of learning at a particular time but do not offer insight about student learning, specifically, whether the course changed the way students think and whether there has been knowledge gain. Thirdly, standard approaches are designed to offer uniform assessment, which do not account for any difference between students in terms of their current knowledge, experiences, culture or background, and could benefit or disadvantage some students. Research by Gipps and Stobart (2009) supports this view and argues that the quest to standardise assessment can introduce bias and fail to provide an equal chance for all students. Fourthly, traditional assessment tends to be inauthentic and far removed from the skills expected outside of the classroom. For example, submission of an unedited essay, such as is usual in an exam, is not an activity that will ever be expected in the workplace. Writers trying to communicate ideas or information are highly unlikely to submit the first draft of a piece of writing for publication in any workplace situation (Nieminen et al., 2022). Lastly, traditional assessments are inclined to measure skills that are becoming obsolete (Swiecki et al., 2022). For example, a psychology student learning about statistical analysis does not need to learn the mathematical calculations for statistical tests. In research and practice, specialised software is used to complete the analysis, and most researchers in the social sciences who use statistics often cannot complete the equations manually.

Regardless of the problematic nature of the standard assessment paradigm, it remains immutable and ubiquitous in higher education. The institutionalised nature of assessment in educational culture can be seen in how assessment is related to quality management policies and the requirement of measuring the effectiveness and the transferability of the learning outcomes (Ashwin et al., 2016; Boud, 2017; Carless, 2017; Dawson et al., 2020). It is, therefore, not surprising that the most significant change in assessment is not caused by drivers from within higher education institutions but rather by external forces in society like technological development and a pandemic.

3. EMERGENCY REMOTE TEACHING OR EMERGENCY REMOTE ASSESSMENT

The COVID-19 pandemic and associated lockdowns forced traditional face-to-face universities to ‘pivot’ their teaching and learning online. This rapid shift from face-to-face to fully online delivery has been termed Emergency Remote Teaching (ERT). This concept is useful as moving online is not a simple process and, under ideal conditions, would take considerable time to plan and execute properly (Hodges et al., 2020). Assessment during this time similarly transitioned to Emergency

Remote Assessment (Dawson et al., 2020). For many departments and disciplines, this meant that assignments and tests were moved online, mediated by an institutionally supported Learning Management Systems (LMS) or other specialised assessment software. These were used to create online quizzes, projects, and tests, and as submission portals for essays, portfolios, and other offline assignments. The use of similarity checkers for text submissions was often deemed a critical part of the assignment completion.[8] It is well established that assessment and teaching influence one another and the rapid shift to teaching online overshadowed assessment design in the early parts of ERT. Most academics were unfamiliar with online teaching and thinking carefully about online assessment was an addition burden in a very stressful situation. Some academics did little to adjust their teaching and assessment for an online context but simply replicated their face-to-face offering online (Eaton, 2020).

The shift to online assessment evoked an immediate concern from the global higher education community regarding how to ensure the reliability and validity of assessments. This concern was further heightened by issues of assessment security for summative assessments especially for those that had previously been closed-book, in-person and invigilated (Bilen & Matros, 2021; Elzainy et al., 2020; Verhoef et al., 2022; Verhoef & Coetser, 2021). The presumption being that online assessment would enable students to be academically dishonest or, to put it simply, cheat in various ways (Dawson, 2020).

The research on student cheating in summative assessments prior to the pandemic is divergent in its opinions on the extent of the problem (Bretag et al., 2019; King et al., 2009; Lee, 2019). It is notable, however, that these findings are not based on the actual tracking of cheating behaviour but rather on the self-reporting of students via survey or interview. The socially constructed nature of cheating further complicates the picture. Cheating is contextualised and the definition differs between institutions and social settings and therefore needs to be negotiated and communicated carefully (Dawson, 2020). This trend is congruent with research carried out in the South African context. It was noted that there was an increase in the number of reported plagiarism cases during the pandemic and a similar rise in the reporting of academic dishonesty, including formal disciplinary procedures initiated against students (Council of Higher Education, 2021; Mutongoza, 2021; Verhoef & Coetser, 2021). Notably, there was a substantial increase in the number of plagiarism cases at our institution, but this coincided with a similar increase in usage of similarity-checking software during the pandemic. Eaton (2020) makes a similar observation about the rise in plagiarism cases and adds that at her institution, many academics operate from the assumption that students cheat. This default position shapes academics' approach to assessment and to students and creates an antagonistic relationship between academics and students. This foundation of a relationship of mistrust could, from the outset, be a major hurdle for any rethinking of assessment practices.

Nationally, institutions and academic departments responded to these challenges in different ways. Many STEM disciplines could not complete laboratory practical's and deferred some assessment tasks

[8]Whilst many refer to similarity checkers as plagiarism checkers – no true 'plagiarism checker' is in existence. These tools simply check for similarity in text.

to a time when students would be allowed on campus. Various mathematics and statistics departments similarly deferred their assessments to when students could return to campuses to mitigate against the use of online mathematical problem solvers and different paid services that could be contracted to solve complex problems. This was not deemed a significant issue in the social sciences, and in these disciplines, assessments were moved online (Pallitt & Kramm, 2022). These disciplines had little concern for formative assessment quality as students would, under normal conditions, have had to write a report, essay, or reflective writing for a mark and feedback. The more significant problem was around summative assessment, which tended to be test or exam-based and invigilated in a face-to-face setting with no access to study notes. During the pandemic, with students studying at home, the exam circumstances could not be simply replicated, and it soon emerged as an important challenge for most departments (Gamage et al., 2020; Moyo, 2020; Mutongoza, 2021).

The drive to secure online assessments resulted in some institutions buying exam proctoring software (Kaisara & Bwalya, 2023). These products record and monitor students, either by an artificial intelligence or human invigilator, flagging any suspicious behaviour that could suggest cheating is occurring during a session. These systems could also lock down the student's system and limit access to websites and specified software, and monitor every click and letter typed on the student's device. From a reliability, validity, and integrity perspective, this seemed like an ideal solution to the problem posed by ERT. However, the literature shows that proctoring services do not consider the differences in quality of student's devices and the bandwidth/internet speeds requirement by students needed to use the service optimally (Kaisara & Bwalya, 2023; Pallitt & Kramm, 2022). Some studies have argued that the use of proctoring services is tantamount to surveillance and highlighted the ethical and moral issues concerned with the use of these services, which results in increased stress experienced by students (McKenna, 2022b, 2022a). Other studies have suggested that many of the services have an inherent racial bias that correctly identifies white males but is less accurate on non-white populations, resulting in many non-white students potentially being flagged as cheating the identity test (Meaker, 2023). The services have also been critiqued for being easily fooled by various tactics, thereby rendering the surveillance provided by these solutions obsolete.

In South Africa in particular, a further issue was the lack of ICT infrastructure. This influenced the quality and nature of the teaching and learning. Connectivity and connection speed determined what students could access, how they could access teaching and learning material, and how assessment could be done. The location of students further complicated their abilities to participate in online classes delivered via Zoom or MS Teams. Some even argued that ERT in South Africa needed to be understood as mobile learning and, by extension, mobile assessment (Pallitt & Kramm, 2022). As a response to student access challenges, various institutions advised or required academics to adjust their assessment design to accommodate students and to ensure equitable access for all while maintaining high academic standards.

Many university management teams, academic advisors, and academics had to radically rethink how assessment would be done. This response included adopting an authentic assessment design or extending problem-based learning (Garg & Goel, 2022; Mutongoza & Olawale, 2022). These were decided on to provide a more holistic approach to assessment to ensure academic integrity by making it less possible to cheat if answers cannot be found online by a simple Google search. This meant a break from the traditional assignment or essay to a more challenging form of question. In addition, it meant that summative assessments like tests or exams would not be strictly timed or invigilated. Instead, these were made available for a more extended period ranging from a couple of hours to several days. Of necessity, these assessments were open book which required different types of questions. (Eaton, 2020; Kaisara & Bwalya, 2023).

Various authors argue that this form of assessment supports learning (assessment *for* learning as opposed to assessment *of* learning) and should have been the standard for assessment even before the pandemic (Carless, 2017). The main argument for the use of this form of assessment lies in the way in which knowledge is seen and understood. Standard assessment practices focus on knowledge transmission and measure the extent to which students have learnt, determining students' capacity to use appropriate knowledge in a discipline-specific manner and demonstrate the disciplinary way of viewing the world (Ashwin, 2020).

In the aftermath of the pandemic and as lockdowns eased, many institutions brought students back and maintained some of the assessment approaches introduced during national lockdowns. There was also a return to some form of invigilated face-to-face exams, but these tended to be weighted less and shorter, with some departments opting to keep some of the take-home online exams as part of their assessment approach. At the same time, many departments and academics reverted to the tried and tested means of assessment offered by traditional assessments. Regardless of the extent to which this happened, assessment underwent changes that incorporated technologies in the assessment options but also changed the approach to assessment. For some authors, this meant that progress was made in terms of what assessment is and could be in the future, with the pandemic offering a pivotal moment to advance the use of alternative and authentic assessment (McKenna et al., 2023).

4. ARTIFICIAL INTELLIGENCE AND ASSESSMENT

Technology was the saviour of the academic project during the COVID-19 pandemic lockdowns. It enabled teaching, learning, and assessment to continue, but it would also create the next threat to assessment in the form of a readily accessible Generative Artificial Intelligence (Gen-AI)[9] chatbot, Chat-GPT. ChatGPT is a Large Language Model (LLM) that uses machine learning and an algorithm that responds to a text input in a chat format in natural human language and produces responses based on the data set on which it is trained (Alkaissi & McFarlane, 2023). One can simply ask it a question, and it creates an understandable output. The output is created based on a probability logic of what the next word in a sentence should be on a specific topic. The LLM has no semantic understanding of what it is writing but produces a seemingly credible text output based on the training data. To complicate matters, the output can reference work it has in the database, but it can 'hallucinate'. Hallucinations

[9] ChatGPT is only one GEN-AI available for use and there are numerous LLM's available and under development Google BARD was released. But the early focus is on ChatGPT. Further, text generation is not the only function, but it can create images, music, video and more continue to develop.

occur when the LLM uses the algorithm to complete the output, but it no longer draws from the database meaning ChatGPT creates a response not based on facts (Alkaissi & McFarlane, 2023, 2023; Arif et al., 2023). ChatGPT's disruptive ability to create, in a manner of seconds, an entire essay which can receive a passing grade, immediately presented a significant threat to the integrity of assessment (Cotton et al., 2023; Rudra, 2023).

The first concern about Gen-AI was the possibility that students might use it to complete online or take-home assessments and thereby 'cheat' by submitting the AI output as their own work (Cotton et al., 2023; Jürgen et al., 2023). Early responses from some institutions were an outright banning of ChatGPT from their institutional networks to prevent student access to the chatbot (De Clercq, 2023). Many of these have since been reversed as the genie is out of the proverbial bottle. ChatGPT is not the only Gen-AI available online and the algorithm is resold in a variety of wrappers and is even available on mobile applications stores[10] (Jürgen et al., 2023). In contrast, other institutions took a more proactive approach, embracing the technology as part of the teaching, learning, and research process, seeing it as an integral part of writing in the future. These institutions went as far as creating guidelines on how to use the technology responsibly and ethically and even provided a way for students to cite the output of a Gen-AI used (Monash University, n.d.; Rosenblatt, 2023).

The relatively easy pivot from the social sciences during the pandemic to take-home assessments, usually in the form of essays, was now under substantial threat from a technology that could generate passing grade essays in under a minute (Jürgen et al., 2023; Marche, 2022). A knee-jerk reaction from most institutions was the limiting of online assessment and a move to face-to-face invigilated assessment to prevent the use of Gen-AI (Lametti, 2022). This problem of generated essays is compounded by the absence of a tool that can reliably identify and distinguish AI-generated text from human-written text. Where tools claim this capability, the terms and conditions outline that the service is not liable if they get it wrong and that no academic sanctions should be instituted against a student if this is the only piece of evidence (D'Agostino, 2023; Gluska, 2023). Most have a low efficacy with OpenAI, the creators of ChatGPT, claiming to only identify about 10 to 15% of AI-generated content. While some claim a much higher level of confidence, a recent statement has shown this to be less reliable than believed (Bearman et al., 2023; Fowler, 2023; Webb, 2023). The rapid advent of Gen-AI has left a policy vacuum in many institutions. In South Africa, for example, most institutions have a policy on plagiarism with appropriate differentiation of level of violation etc. However, academic integrity more broadly is far less well defined, and the violations thereof are likewise poorly defined. The consequence is that plagiarism policies are being drawn on as a rather blunt and inappropriate tool to consider issues of AI usage where the student has not declared the usage. From a legal perspective, the use of AI has no definition in the law at the current stage and would need a case to formulate the law. Many lawyers and university managers are now trying to determine if the undisclosed use of Gen-AI should be understood as plagiarism or fraud (Glanville & Yue, 2023).

[10] Wrappers are online software applications reselling a unique brand and/or product that is powered by another. In this case OpenAI's algorithm being used to power the LLM function on other websites.

Another group of researchers has argued against the idea of spending significant resources on AI detectors, claiming that a 'catch-and-punish' approach has not worked for plagiarism, and therefore would most likely not work in preventing the use of AI (McKenna et al., 2023). Research suggests that the deployment of similarity checkers has not resulted in a reduction of plagiarism cases, and in some cases, it increased similarly as we have seen with the increase of cases during ERT (Arsyad et al., 2022; McKenna, 2022b; Mutongoza & Olawale, 2022). McKenna (2022b) argues that when catch-and-punish is the goal of similarity checkers rather than usage as a formative tool, educators are misunderstanding on why we have the software. Some authors argue that in the time of AI and the wealth of information available, we need to transcend the confines of plagiarism to a post plagiarism era where a catch-and-punish is not commodified but rather violations are used as part of the education process (Eaton, 2021). The post plagiarism approach to writing may be urgently required as the evolution of technology may shift the focus on the ideas and knowledge contained in the text and not the sole focus on the writing itself.

5. PARALLELS BETWEEN ERA AND AI

The move to online learning during the pandemic and the advent of AI shares some similarities in the response from higher education in general. Firstly, the initial reaction was a concern for academic integrity, which developed during ERT and online assessment, and the advent of Gen-AI has continued the relationship of mistrust. Plagiarism and the use of detection software increased during the pandemic, and the catching and policing of plagiarism seems to be ingrained, as is the use of the similarity checking software (Eaton, 2020). With the development of Gen-AI, a similar mindset has prevailed, with many academics wanting detectors to be developed to use the same catch-and-police approach. Such detectors are not likely in the short to medium term and this has left a vacuum for most higher education institutions on how to deal with Gen-AI in teaching, learning, and assessment. The knee-jerk response to shifting assessment back to invigilated face-to-face exams and tests as a response to Gen-AI is like that of many STEM disciplines who deferred their assessments until campus access was restored or other disciplines who used proctoring services. Where STEM disciplines were particularly vulnerable during the pandemic through human problem-solving services, this is now shared across most disciplines. The final similarity is the response many universities and academic development departments advised: a change in assessment design. ERT and Gen-AI both provide a push to rethink assessment in radical ways, to change the mode of assessment and the way assessment is designed to be more authentic and more sustainable, and to challenge the role of summative assessment in the format of an exam. The question is how we should rethink assessment design during the time of AI with constant change. We argue that a focus on knowledge is central.

One of the major issues highlighted at the beginning of this paper is that assessment practices have not changed substantially over the last half-century. Where technology is used, it is usually simply enhancing the efficiency of an established model. For example, MCQs, which used to be paper based, can now be automated through many Learning Management Systems. What we need is a different way to think about assessment. However, we need to be sure that our assessments are testing what we think they are testing. Using chemistry as an example, Rootman-le Grange and Blackie (2018) offer a rather sobering analysis of the exams of an introductory chemistry course and found the weakness of established assessment designs. This analysis is endorsed by Stowe and co-workers (2021) in their paper 'You are what you assess'.

This recognition of the limitations of current assessment practices leaves a little bit of conundrum. It is challenging to think up new ways of assessing. One solution to this problem is to consider carefully what knowledge construction looks like in a particular field. Scaffolding knowledge construction is discipline specific. Knowledge construction in chemistry will necessarily not be the same as knowledge construction in sociology. Nonetheless, making visible the kinds of knowledge that need to be integrated for mastery of a field will assist in developing appropriate assessments.

As an example, Blackie (2022) illustrates the way in which this works in organic chemistry. In this paper, she describes four kinds of knowledge – knowing the fact, knowing how, knowing why, and powerful knowledge. In Table 1, taken from Blackie (2022), these kinds of knowledge are linked to different categories of questions that could be asked on a standard invigilated assessment. However, this differentiation can also be used to create different kinds of assessment tasks. 'Vocabulary' questions are most meaningfully assessed in a closed book in person, invigilated setting. For this kind of assessment, there are clear right and wrong answers, and a relatively high pass mark (e.g., 80%) is appropriate. 'New problems' in this context could include asking a student to look up a new laboratory procedure and adapt the procedure given the equipment they have available to them. This kind of assessment could be fully open in terms of access to people, information, and tools (Dawson et al., 2023). Some formative assessments focusing on procedural competence, for example, working on complex problems, could be best implemented with group work and access to class notes.

Table 1: The relationship between categories of question and kinds of knowledge (Blackie, 2022)

<table>
<tr><th>Category
(Choose those categories that are necessary to the environment)</th><th>Example of the nature of the question (needs adaptation for each environment)</th><th>Kind of knowledge (This column can be retained or omitted.)</th></tr>
<tr><td>Vocabulary</td><td>information that must be learned</td><td>Knowing the fact</td></tr>
<tr><td>Simple procedure</td><td>Single step calculation
Give reagent/product.
/Starting material
Recognising a reaction type</td><td rowspan="2">Knowing how</td></tr>
<tr><td>Complex procedure</td><td>multistep calculation
Known mechanism
multistep synthesis
Explanation of known scenario</td></tr>
<tr><td>Principle</td><td>explanation applied to a new scenario.
fill in the gaps on a new mechanism</td><td>Knowing why</td></tr>
</table>

Category (Choose those categories that are necessary to the environment)	Example of the nature of the question (needs adaptation for each environment)	Kind of knowledge (This column can be retained or omitted.)
New Problem	Application of knowledge to a new scenario	Powerful knowledge

Mastery of chemistry requires all these kinds of knowledge. Rote learning of some of the information will assist in lowering the cognitive load of the course overall. But with a differentiated assessment approach, the threat of Gen-AI gets reduced – it can't be used in the same way for all assessment tasks. More importantly, the scaffolding of knowledge is made visible to the student. This approach has the potential to set the student up for life-long learning in a far more meaningful way.

In a discipline such as sociology, the weighting and application of different knowledges will not be the same as it is in chemistry. Nonetheless, skills such as identifying the points to be covered in an argument can be separated from the skill of locating the antecedents of those points in the literature and skill of writing a coherent paragraph. There are undoubtedly other elements that could be identified, but even with these three, it is evident how different kinds of assessment could be used to assess mastery of each component. Writing a take-home essay, which is still likely to be an important assessment task, is then just one assessment among many.

When taking a knowledge construction approach, the guiding principle must be 'What does it take to attain powerful knowledge in this discipline?' Powerful knowledge encompasses the acquisition of recognised disciplinary knowledge and the capacity to enact that knowledge to affect the world in some way (Ashwin, 2020).

6. WHERE DOES THAT LEAVE US?

If the focus of assessment is knowledge construction, then equipping students with ways to work with powerful knowledge in the disruptive time of AI needs to be reconsidered. AI has impressive strengths and abilities but some limitations for the time being. We need to focus our assessment on the areas where AI has limits, and this could look very different in various disciplines and contexts (Bearman & Luckin, 2020). Boud's (2000) work on sustainable assessment could be useful for us to determine how assessment could be designed with a focus on how students learn to deal with problems that can be solved with the powerful knowledge students are exposed to and would enable students to apply this knowledge to new situations. Another key idea is evaluative judgement. As information is readily available in the information age and Gen-AI can produce content rapidly and would likely be a big part of the future workplace, developing critical capacities to evaluate what makes sense and what does not in different fields will become a pivotal skill to produce and evaluate quality (Tai et al., 2018).

7. CONCLUSION

The panic around AI and assessment in higher education could be viewed as a disruptive technology that will transform society, work, and education. In fact, it may change the world in fundamental ways which we cannot anticipate yet. Predicting the future is a fool's errand, but we have argued that many of the problems Gen-AI has brought to higher education are new, but they have some significant similarities with ERT and how this influenced assessment. Hopes of identifying AI writing do not look promising, and higher education institutions need to find a response that addresses context and disciplinary differences. We have further argued that a focus on knowledge construction is vital to developing a response to Gen-AI and the existential threat it has on teaching, learning, and assessment. With this focus on higher education as a sector, individual lecturers could rethink assessment, move away from monolithic assessment, and shift to a more diversified approach that fosters knowledge construction. Higher education institutions have three choices: we can either move backwards to exams and the invigilated face-to-face models of assessment, we could avoid Gen-AI and hope it is resolved when a detector is developed, or we could rethink what assessment means now and what it could look like in the year 2030.

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LEAPING FORWARD WITHOUT LOSING SIGHT OF THE PAST: A COLLECTIVE REFLECTION ON THE FUTURE OF MOBILE LEARNING

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ABSTRACT

This paper presents the viewpoints of six international scholars who reflect on how they see mobile learning (ML) becoming its future self by reflecting on its past. Each scholar reflects on ML learning into the future with an eye towards the evolving nature of ML theory, alternative philosophical perspectives, associated pedagogy and practice, design and research practices and methods in ML, and emerging technologies relevant to ML. Along the way, they explore the potential impact—both positive and negative of adoption or non-adoption of ML in education and lifelong learning settings.

Keywords: mobile learning; seamless learning; hybrid learning; collaborative writing

1. INTRODUCTION

Mobile learning (ML) research is a rapidly evolving field that explores how mobile devices can support learning anytime and anywhere, in an (more) efficient, effective, and enjoyable manner. ML has been influenced by various social, cultural, and technological changes over the past decades and by different theoretical and pedagogical perspectives. However, as ML becomes more widespread and diverse, it faces new challenges and opportunities requiring critical reflection and inquiry. In this paper, we aim to provide a productive space to reflect upon and question how ML is positioned more generally in the technology-enhanced learning (TEL) and (digital) education domain. Our main objective of this collective reflection is to explore the past, present, and future of ML from different angles and perspectives.

To write this collective paper, we used the collaborative writing technique, characterised by "openness, collaboration, co-creation and co-social innovation, and collegiality that becomes a praxis of self-reflection of the subjectivity of writing" (Peters et al., 2022). We are six international scholars involved in ML research and practice for several years. We wrote collectively online and held synchronous meetings to reflect on our writings collectively. As we wrote and met together, the discussions splintered and converged. The process resulted in the collection of a range of perspectives, philosophical approaches, and values.

The contributions are organised as follows: Parsons provides a historical overview of ML pedagogies and theories as they emerged in relation to changing social forces and technologies. While Parson's contribution is more retrospective, Koole dives into philosophical/theoretical areas that challenge current perspectives in educational technology: socio-materialism and the post digital. Rusman delves into mobile and seamless learning design, examining both process and outcome perspectives on learning design. MacCallum then discusses the concept of affordances in relation to recent innovations in ML and explores how new technologies offer new affordances and barriers that need to be overcome as we move towards a new vision for ML. Cristol's contribution shifts into the 'digital deserts' issue in Ohio, where limited connectivity is essential for providing people access to banking, education, medical systems, and other key social and economic services. Finally, Arnedillo-Sánchez discusses the potential implication of unfettered access to mobile technologies in children's motor, brain, and emotional development.

To conclude, the authors engage in a discussion that explores the commonalities, divergences, and, most intriguingly, the tensions among the various perspectives presented throughout this collective paper. By engaging with the past, embracing diverse theoretical frameworks, examining design implications, addressing societal challenges, and considering developmental aspects, this paper strives to provide a comprehensive and nuanced reflection on the future of ML.

2. THE EVOLVING NATURE OF MOBILE LEARNING PEDAGOGY AND THEORY (PARSONS)

For mobile technologies to be effectively used in education, a rationale is needed for selecting appropriate pedagogies and their underlying learning theories. Over the years, different aspects of ML have come to the fore as both the technology and its contexts of use have evolved. In the early days of using mobile devices for learning, from the late 1990s, the limited affordances of the available devices led to pedagogies based on having a device that could communicate (via calls or text messages) and could be carried into different learning spaces. Therefore, pedagogical practices based on theories such as self-directed learning and social constructivism were put forward as being relevant approaches to ML (Stone & Thames, 2004; Zurita & Nussbaum, 2004).

Ten years or so later, as mobile devices became more powerful, with fast Internet connections, application processing and multimedia capabilities, new types of learning became possible. Informal learning became a realistic prospect, while more constructionist learning activities could be undertaken on more powerful devices (Siemens, 2005), using the increasing number of apps and coding tools available that supported the creation of digital artefacts (Anohah et al., 2017). More effective types of experiential learning became possible with devices that could interact with environments both physical and virtual, for example through location awareness and an increasing range of sensors that enabled the gathering of data for inquiry-based learning. An increasing range of media types meant greater support for different modes of learning, both in terms of the learning materials provided and those created by the students with devices that could handle high-quality images, videos, and sound.

Perhaps the most important technological change to impact ML recently has been artificial intelligence tools. For example, given a latitude and a longitude from a mobile device, tools such as ChatGPT can provide contextualised, interactive information about a location, opening new possibilities for situated cognition and place-based learning. Other AI features, such as image recognition, can provide further contextual learning opportunities and, combined with the ability to translate, transcribe, and summarise spoken information, AI-driven ML tools can transform what is possible for learners moving within and between contexts. ML practitioners need to consider the potential of mobile devices to offer intelligence both for and about learners, spanning an increasing range of connected devices. Future ML will take place within an environment where mobile devices are the most likely channels for learners to interact with the Internet of Things (Kassab et al., 2019). Learning theories such as situated and distributed cognition can come into play strongly in situations where students have access to a range of smart devices that can be deployed across different environments that may embed various forms of machine intelligence.

Social forces were also important in the evolution of ML. The increasing accessibility and affordability of powerful mobile devices and communications networks globally have made it possible for Bring Your Own Device learning to be at least potentially equitable. The pandemic made it even more important that students have access to Internet-connected digital devices and many students relied on their mobile devices for learning during lockdowns and the closures of educational institutions. However, this may have been a double-edged sword, in that while students' mobile devices may in many cases have been their only link to their teachers during school closures, some schools have attempted to turn the clock back to pre-pandemic styles of teaching. There are now efforts to limit opportunities for ML, for example with recent bans on using phones in schools in Australian states (Selwyn & Aagaard, 2021) despite evidence that such moves may be over-simplistic and counter-productive (Magnusson et al., 2023). In the face of these challenges, it is important that ML theory can make a strong case for the value of learners using mobile devices.

From a social perspective, ML theory has been influenced by sociological work in mobilities. Although the concerns of mobilities research are very different to most ML research, concerned as they are with the movements of people and the underlying forces of those movements, and not necessarily technology or learning, the field nonetheless embraces concepts of communicative, imaginative, and virtual mobilities that link closely with contemporary ML spaces. Perhaps more important are the broad social issues that are addressed, such as mobility constraints, surveillance, and inequality (Sheller, 2017). Such theoretical concerns also find a place in the processes of decolonising learning and the idea that ML needs to find a role that is unique, universal, and outside the established paradigm (Traxler, 2021).

Given these technological innovations and the social forces at play around them, what does this mean for the theory and pedagogy of ML? Several new theories of learning have been proposed in the 21st century, including some discussion of what a theory of ML might include (Sharples et al., 2005). However, the 21st century learning theory that has gained the most traction is connectivism (Siemens, 2005). Although it has been criticised for a lack of rigour as a learning theory, it has found a role in informing curriculum design (Bell, 2011). In its early days, one criticism was that not everyone believed the connectivism principle that learning may reside in non-human appliances (Kop & Hill, 2008). With the recent spread of tools based on large language models, this seems to be far more self-evident than it was when the theory was first developed, and therefore it would be relevant to reinterpret connectivism as a theory and how it may apply to ML pedagogies going forward. The pedagogical challenge is to ensure that learners are still able to construct their own knowledge in a world of intelligent, connected, mobile machines. In addition, ML pedagogies must take a broader social view that embodies an understanding of the inequalities and ideologies that have driven past practice to bring us to where we are today and ensure that future ML is justifiable, equitable, decolonised, and more human than machine.

3. MOBILE LEARNING: NOT QUITE POSTDIGITAL (KOOLE)

Since the term 'mobile learning' (ML) was coined, multiple definitions have emerged suggesting differing primary foci such as technology, pedagogy, mobilities, disruption, or other areas deemed significant to researchers. In his critical review of ML, Traxler (2021) notes that definitions of ML generally suggest "learning mediated by personal connected mobile digital technologies" (p. 6). He argues that within the field, conceptions of learning remain "unchanged" (p. 6) and have not reflected societal change nor challenged the "epistemological foundations of our worlds and cultures" (p. 7). There is much value in Traxler's critique. To create space for growth in ML research, it may be helpful to consider ML from different ontological and epistemological perspectives such as socio-materialism and/or the post digital.

Traxler's comment above reveals the often-binary way of viewing ML in terms of a human-technology divide. Socio-materialism offers an ontological 'sensitivity' which can assist in understanding patterns and unpredictability in the surrounding world (Fenwick & Landri, 2012). Within this view, the human and non-human are part of assemblages whose very ontological nature mutates as components of the assemblage shift. Assemblages can be conceptualised in many ways through many metaphorical patterns such as fluids, networks, and regions (Koole, Clark, Hellsten-Bzovey et al., 2021). More importantly, a socio-materialist would suggest that ML involves learners, content/procedures-to-be-learned, and tools (devices, networks to permit access and interaction with content). All such elements within the assemblage are interconnected in sometimes messy and unexpected ways. If, for example, the device is a smartphone, the nature of learning is co-created by the smartphone; however, if instead uses a laptop, the nature of the learning activity may shift. Using a smartphone, the learner might quickly turn it on while waiting for a bus, turn it off while getting on the bus, then turn it on after taking a seat or finding a spot to stand. Using a laptop, the learner might find it too cumbersome to turn it on and off so frequently—especially if all the seats on the bus are taken.

Barad's (2007) concept of intra-action accounts for an "entangled state of agencies" within assemblages (p. 23) in which "distinct agencies do not precede, but rather emerge through, their intra-action" (p. 33). In considering the bus example above, the ability to access learning materials changes in accordance with the technology and its affordances, the nature of the learning content, and the preferences of the learners. At the same time, Barad's concept of intra-action challenges essentialist ideas of causality in which one entity acts upon another entity; rather, reality co-emerges or co-performs into existence. Within this view, learning is performative alongside the human, digital, and material which are co-present. The emergent performance is unique to that assemblage. This situation partly explains why educators can only design for learning (Laurillard, 2016) rather than designing actual, prescribed step-by-step learning trajectories along with specified outcomes (Parchoma et al., 2019). ML—along with every other type of learning—is contingent upon its assemblage.

The socio-material is complementary to the post digital perspective. However, the post digital focuses on continua between analog and digital, and between old and new. Unlike the use of 'post' (meaning 'after') in other theoretical perspectives, 'post' in post digital refers to a continuation of the digital but is also beyond the digital. It "neither recognises the distinction between 'old' and 'new' media, nor ideological affirmation of the one or the other. It merges 'old' and 'new'" (Anderson, Cox, & Papadopoulos, 2014, p. 5). For ML to be considered post digital, the digital would need to be so ubiquitous that it is unremarkable and passé (Cascone, 2000; Cramer, 2015)—noticed by its absence rather than its presence (Jandrič, Knox, Besley et al., 2018)—just as one is unconscious of the computer chips and digital goings on in one's car while driving. In the case of ML, learners may lack awareness of how the nature of their interactions might differ when they shift from, say, a smartphone to a laptop, but they remain aware of the actual tool used, suggesting that ML has not yet become post digital. Furthermore, the post digital perspective renders notions of causality (binary views) moot: technology does not 'cause' ML; however, ML cannot exist without technology as part of its assemblage.

The importance of considering alternative perspectives such as the post digital is to surface different realities that can inform the development and selection of learning theories, technologies, and pedagogically effective design. For example, if mobile devices are unremarkable (i.e., they are no longer noticed), then how designers present information/content and design of procedural lessons without learners being aware of learning modalities and platforms? If AI and seamless learning represent movements towards the post digital, and if information is always at hand, is there still a need for people to learn and remember information and procedures? What becomes the focus of pedagogy?

4. A DESIGN PERSPECTIVE ON MOBILE AND SEAMLESS LEARNING (RUSMAN)

The overall objective of mobile and seamless learning design is to influence the cognitive state and behaviour (activities) of learners to reach specific personal (learning) objectives in an environment or practice, through the design of learning scenarios that are leveraged and supported through the optimal combination of pedagogical insights, specific and unique affordances of (mobile) digital technology and an area of interest or domain.

The term 'learning design' can refer both to the design process itself as well as to an envisioned outcome or product of this design process, such as a specific learning scenario. Looking at the term from a process perspective, it is about systematically designing, developing, delivering, and evaluating (digital, physical or blended/physical) learning scenarios to support the acquisition of specific learning objectives by a (group of) learner(s). The design process consists broadly of determining the state, preferences and needs of the learner, defining the end goal of the learning process, and creating a grounded "intervention", based on learning and instruction theory, design frameworks and practice-based information, to assist in the transition (Wagner, 2011). To support the learning design process, different design methods and instruments might be adopted, for example rapid prototyping, design thinking, design research or ADDIE, with instruments such as card sorting, personas, canvases, use cases, scenarios or learner journeys, mock-ups, and 'theoretical' learning models. These design process models vary in the way in which they are prescriptive and deterministic (e.g., the system approach of instructional design by Romiszowski, 1993) compared to more open, cyclic, re-iterative models, in which various stakeholders and actors are part of the design process and the design process is 'fuzzier' (e.g., the design thinking approach, Curedale, 2019). Examples of learning theory used to guide design decisions are constructivist, behaviourist and connectivist or boundary crossing learning approaches. Examples of 'theoretical' instruments are generic frameworks for learning, such the 'conversational framework' (Laurillard, 2002), the Cultural History Activity Theory (CHAT)-framework (Engeström, 1987), as well as specific 'holistic' frameworks for ML, like Kearney's (2012) and Koole's (2005, 2009) frameworks, but also frameworks focusing on specific design factors, for example on the influence of the affective states of learners (Viberg, Kukulska-Holmes & Peeters, 2022) or their agency (Suarez et al., 2018). Looking from a technological perspective, models on specific affordances of mobile devices to support learning and personal development can be used, such as those defined by Sharples et al (2015) and Bannon, Cook & Pachler (2017, p.943). Affordances they mention are collaborative and communicative potential ("connectivity"); interactivity and non-linearity, distributed knowledge construction, multimodal knowledge presentation, authentic/contextualised/situated material, interaction, tasks and settings; multifunctionality and convergence (previously separated tools in one device and connectivity to internet based services, tools, resources and networks); portability ("always with you"), ubiquity, personal ownership and user-generated and created content and contexts ("sensor pack" to extend human senses, multimedia capture, data logging).

The resulting 'intervention' may be called a learning design too, only then from an outcome perspective. From this perspective, a learning design is a formal description of a learning scenario, that may also be expressed in a (re-usable) format. A learning scenario describes (roles of) actors participating in a learning process, the (order, sequence(s) and potential paths through) learning and support activities designed to achieve certain learning objectives in the most efficient, effective and engaging way and the environment (with actors, resources, instruments and services) to support individuals' activities. Actors may include learners, teachers, and experts. A learning design from an outcome or product perspective is a method enabling learners to attain certain learning objectives by performing a series of learning activities in a certain order in the context of a given learning environment (Tattersall et al., 2003). Examples of ML designs from an outcome perspective are e.g., more (inter)active learning scenarios, such as inquiry-based-, story-telling-and making, game-based and problem-based ML, but also more 'delivery' focused designs, such as micro-learning modules. Within these scenarios, design elements with specific designed affordances may be distinguished, such as for example triggers, nudges, and notifications (Rusman, 2019). These may be considered as 'building blocks' within a mobile (inter)active learning scenario.

Within each of these perspectives (process and product/outcome perspective) several layers can be distinguished in which informed and complex design decisions need to be made, dependent on the characteristics of the learners, the learning problem(s) and the environment(s) they are active in and the added value and affordances of mobile technology. The control on these design decisions can be with one or more of the following actors: researchers, designers, teachers, domain experts, students, but also be machine automated or supported.

Looking at existing research on learning design at various levels/layers and from different perspectives, it is noticeable that over the years the design methods to address ML design processes have been shifting from more prescriptive models towards more open and cyclic methods, with stakeholder involvement within the design process. However, as it is often argued that this kind of design approach fits the kind of complexity of the design problems best and can still contribute to theory development within the ML as well as the learning design domain, it is not clear on which aspect of the design process or of the design outcome this theory development can and should happen. It is rare that structural comparison of learning design solutions of comparable learning problems and the underlying rationales and considerations behind (chains of) design decisions during the learning design process are made. Notwithstanding, this could probably lead to the detection of most optimal design 'constellations' of design solutions to specific type of problem sets and design guidelines. Moreover, more insight into the design process itself could be gained, based on the analysis of the chains of design decisions at various layers that led to these constellations. These design decision chains may also be called the 'learning design pathways. However, currently little is known from a structural perspective about optimal design pathways to create the most effective, efficient, and enjoyable ML designs and the structural characteristics of these designed 'constellations' linked to specific learning problems in practice. Several learning theories and models are often used, based on the assumption that they are fitting and effective, however structural evidence remains absent. With reflection on the design methods used to structure the design process it is a similar case. Moreover, learning solutions are also often still linked to formal education only, for specific target groups (e.g., upper classes K-12 education), embedded in specific domains (e.g., language learning, mathematics (geometry) and (environmental) sciences) or focused on improving specific characteristics or steps in the learning process (e.g., improving reflection, supporting self-reflection, emotion-regulation, (peer)feedback or learners' agency). Yet did we generate 'overarching' (design) knowledge about the inherent characteristics of these contexts that make mobile and seamless learning designs especially feasible or effective there? And do we know more about (specific chains of design) decisions within the design processes that have led to these presumably optimal 'design constellations?

Therefore, looking at potential new alleys and perspectives for future research on mobile and seamless learning design, more structural and standardised expression and analysis of both design pathways (chains and layers of design decisions) and the design methods used as well as their relation to optimal 'constellations' of learning design solutions could provide further knowledge and insight in general principles, mechanisms and guidelines for the design of mobile and seamless learning solutions. As Buchanan (1992, p.6) stated 'designers are exploring concrete integrations of knowledge that will combine theory with practice for new productive purposes. However, as researchers, we should not forget to look for more generalisable knowledge that can potentially be derived and distracted when looking at the characteristics of collections of unique, 'one and only' design solutions. Potentially, design patterns could fulfil a role in expressing designs and uniting both practice-as well as theory-based perspectives when solving learning problems. "*Design patterns provide a structure for integrating the analysis and solution of a problem, in a way that is sensitive to context and informed by theory and evidence*" (p.3, E-LEN project). In a design pattern special attention is given to the forces which are acting on the problem and the rational for choosing a particular solution (p.2493, Baggetun, Rusman & Pozzi, 2004; Goodyear et al., 2004; Laurillard, 2012)". However, also other manners to elicit (pattens of) generalisable elements of both the mobile and seamless learning design process as well as the learning design outcome, in relation to structural characteristics of re-occurring problem situations, could be explored in future studies. Such as in the recent study of Cochrane et al. (2022), in which they used a combination of activity theory and the DTML-PAH matrix to express and analyse the characteristics of seven case studies. Potentially, recent AI development could play a role in detecting recurring patterns of design, both in terms of (chains of) design decisions as well as in terms of optimal 'design constellations' for specific problem types in educational practice.

5. THE AFFORDANCES OF NEW TECHNOLOGIES IN MOBILE LEARNING (MACCALLUM)

Much of the research into, and adoption of, ML has been driven by the unique affordances that mobile technology offers. Affordances can be either intended or unintended, and it is unlikely that the developers of mobile devices gave much thought to their learning potential, yet their learning affordances were quickly recognised. For example, some of the designed and therefore intended consequences of mobile devices are their portability and the ability to connect to networks and resources. From a ML perspective, an unintended consequence of these affordances is that learning can take place anywhere and anytime (Pimmer et al., 2016). In general, as mobile technology has evolved to offer more features, it has in turn enabled mobile learners to identify new affordances.

With ongoing research, many different ML affordances have been perceived in mobile technology. These include but are not limited to, the ability of mobile technology to support outdoor learning, engage in enhanced social communication, provide for the gathering of evidence and data, and support interaction with other learners' devices (Parsons, et al, 2016). These affordances provide an insight into the "possibilities for action" afforded by the technical design and features of mobile technology (Markus & Silver, 2008). However, as we consider the future of ML, new affordances will need to be identified and leveraged for ML to continue to make its mark in the education space.

As enhancements are made to current mobile technologies, this will in turn continue to promote new opportunities for ML. For example, innovations in mobile extended reality (XR), which includes both virtual reality (VR) and augmented reality (AR), have provided opportunities for more affordable access to sophisticated learning experiences that don't need specialist equipment to engage with, enabling student-created experiences (MacCallum, 2022). In addition, newer technologies like LiDAR have provided for more precise augmentation of physical objects within the digital space, therefore, opening richer and more precise context-aware AR learning (Lin, et al, 2022).

While new features on mobile devices may provide unique opportunities in themselves, the systems that these devices connect to may provide the most significant opportunities for new learning experiences. For example, learning analytics systems running in the cloud can support learners using mobile devices (Pappas et al., 2017), and the Internet of Things (IoT) supports person-to-machine interactions that enable IoT-based instruction in contexts such as the smart campus (Zeinab et al., 2022). Also, new AI technologies, coupled with mobile technology, may provide new learning opportunities. For example, through Generative AI, the creation of learning artefacts, such as videos, presentations, and even AR and VR experiences, can be sped up to remove the unnecessary repetitive work and allow for more focus on the creation of ideas and deeper understanding. This could include creating engaging learning opportunities that utilise both AI and mobile technology, such as those envisioned by Raptis, et al, (2021), where mobile technology and AI may be combined to support contextual and personalised information based on learner engagement with Art exhibits.

As we look to the future of ML, there is an opportunity to explore what new affordances are offered by mobile and its additive technologies, and how we can harness them to ensure that ML remains relevant in the future. However, this focus on affordance should not be mistaken as being simply techno centric. Rather, while technologies can suggest potential uses it is for the educator to evaluate the value of the tool in learning. Technology may provide new opportunities, but educators must judge if their use also brings worthwhile learning that is not impeded or inhibited because of the tool.

While exploring affordances, is important to acknowledge the challenges that ML brings. Their ubiquity means they are often seen as a classroom distraction, a negative affordance (Maier et al., 2009), and their use is often constrained by schools. Another challenge is the commodification of education, which has led to companies competing for attention and trying to sell the latest gadget promising to be the "silver bullet" to improve learning, often neglecting or undermining valid concerns related to privacy, data security, and the potential for intentional integration of addictive features embedded within these systems. Therefore, while we consider how new technologies may support new opportunities it is important to recognise the potential negative impacts that digital and mobile technology has on our learners (Cloete, 2017).

Taking an affordance lens to the exploration of ML must also include consideration of responsible and effective use of mobile technology in education, where learning takes precedence and where proactive measures must be taken. This entails implementing strategies to manage distractions, fostering a balance between digital and personal interactions, promoting critical thinking skills to combat misinformation, and working towards bridging the digital divide. It is crucial that we maintain a critical perspective regarding the role of technology in education, considering the interests and potential risks posed by its integration. As we progress towards the post digital era, mobile technology will play an even more decisive role, where its ubiquity and accessibility place powerful opportunities in the hands of learners. This power will come with strong caveats that we, as educators, need to explore alongside our students for the opportunities to be truly realised.

6. TURNING DIGITAL DESERTS INTO DIGITAL RAINFORESTS (CRISTOL)

Prior to the Covid-19 pandemic, the term digital divide was an often-used theoretical explanation for households lacking access to reliable broadband internet services (Gorski, P. 2005). Then Covid-19 took its grip on the global community, triggering the education of students at all academic levels, abruptly shifting from primarily face-to-face learning to remote learning. Immediately, students, parents, educators, and administrators in some communities around the world experienced unreliable or no broadband internet services consequently losing the ability to continue or limit formal learning (Dorn, et al, 2020). No longer was this a theoretical problem; this became a tangible educational-survival problem. The problem was like a desert lacking nourishment and water to sustain life; these communities became digital deserts lacking the technological nourishments to sustain learning outside of the classroom (Beaunoyer, 2020).

Digital deserts refer to areas or communities that lack access to reliable and affordable internet connectivity and digital technology (Levin & Downes, 2019). In educational digital deserts, students have difficulty completing their schoolwork or participating in online learning opportunities. This exacerbates existing inequalities and limits economic and social mobility for residents in these communities (Crock Bauerly et al, 2019). Many digital deserts are found in rural or urban communities which are economically disadvantaged and thus facing challenges to access education, job opportunities, critical information, and services available online. These deserts are not a Covid-19 phenomenon, some communities could have been labelled digital deserts prior to the pandemic. For example, in remote rural Bangladesh, communities faced many teaching and learning obstacles caused by lacking access to sustainable and reliable internet connectivity. Instead of experimenting with the current learning technology commonly found in developed countries, the primary experimentation in these communities was to find reliable electricity to function as a thriving community. Despite these circumstances, most parents viewed technology to help their children succeed in school and future jobs

(Cristol et al, 2019). For those residents living in developing countries' digital deserts, the notion of digital ubiquitousness is a foreign concept and unattainable, unless one argues their cars contain microchips, a measure of their participation in the digital sphere.

To nourish digital deserts into thriving digital communities, some political, business, and educational leaders are engaging multiple stakeholders. Some examples of these interactions include providing government subsidies for broadband internet infrastructure and regulatory reforms; community-based technology training programs and digital literacy programs; and partnerships between public and private organisations to expand access to digital services (Shakina, et al, 2021). These endeavours require a multifaceted approach involving investment, collaboration, and innovation across multiple sectors (Light, 2001).

In the United States, Ohio stakeholders are actively working to expand access to 5G and broadband internet across the state, particularly in rural and underserved areas. In 2019, these stakeholders created the Ohio Broadband Strategy (Ohio Broadband Strategy, 2023) to streamline the deployment of small cell wireless technology, which is necessary for the implementation of 5G and broadband internet. The belief is that the strategy will help neglected communities be on a more equal footing throughout the state, create jobs, boost the economy, and improve the quality of life for residents (Genetin, et al, 2022).

Recognising the urgency of the need, the immediate target is the training and education of the workforce with short turnaround times to be a workforce ready for sector-wide employment and advancement. The strategy uses a comprehensive and systematic process consisting of (1) professional awareness programs that aim to introduce 5G and broadband internet concepts and possibilities at middle- and high-schools (grades 6-12); (2) professional workforce development programs that develop an immediately employable workforce and (3) professional innovation programs to train the next generation of technical 5G and broadband internet leaders and executives. The Strategy operates through The Ohio State University (OSU), Broadband Internet & 5G Connectivity Center (Broadband internet & 5G Connectivity Center, 2023), a partnership between OSU and an industry intermediary. The Center houses, develops, disseminates, and administers the educational and workforce development programs. The industry intermediary leads the Sector Partnership, distilling industry needs, and, jointly with the Center, oversees planning and implementation.

While there are many challenges to overcome, there is hope that disenfranchised communities can eventually become equal participants in the larger digital learning community. Efforts, such as Ohio's, are undertaken to turn digital deserts into digital rainforests where all communities can ensure all students will have broadband internet access. By providing broadband internet access to these deserts, disenfranchised and underserved communities can address and challenge long-standing socioeconomic and learning barriers by using the technological offering in the global digital community.

Finally, partnerships such as Ohio's strategy between educational institutions, businesses, political entities, and community organisations provide resources and support for initiatives such as community technology centres, as well as scholarships and other financial assistance to help individuals access digital learning opportunities. While there is still work to be done to ensure that underserved communities are equal players in the digital learning world, these initiatives and efforts are making progress towards greater access and equity.

7. THE IMPACT OF MOBILE TECHNOLOGY ON CHILDHOOD DEVELOPMENT (ARNEDILLO-SÁNCHEZ)

Since its emergence, ML has exerted a disruptive effect on formal education, it has democratised access to learning opportunities and concerned societies regarding the impact technology may have on learning and learners. In recent years, there is growing concern on the negative effects ubiquitous access and endless exposure to screens may have on young children and their development (Wang, Qian, Li & Wu, 2023).

The affordances of mobile technologies: portability, connectivity, interactivity, location awareness, and data collection; have transformed learning paradigms, societies, and social interactions. Application areas where mobile technologies have created new learning opportunities include data collection, location awareness, and collaboration (Patten, Arnedillo-Sánchez, Tangney, 2006). To this end, ML has made learning opportunities more accessible than ever. It has decoupled learning from classrooms, bridged the gap between indoors and outdoors learning, enabled physical, virtual, and augmented learning and its contextualisation, and supported learners to become content creators and learning influencers. Constructivist learning approaches, focused on social interactions and creation of knowledge and artefacts, have championed ML implementations in these domains. However, behaviourist approaches, well suited for mobile devices as they support presenting stimuli, obtaining responses, and providing reinforcement, have prevailed with the upsurge of social media. The quasi-automatic response triggered by a ringing (or tweeting) mobile phone illustrates the stimulus-response bond which is a fundamental tenet of behaviourism (Jordan, Carlile, & Stack, 2008). The convergence of portable, connected mobile technologies, social constructivist practices and interactive/social tools, informed on behaviourist principles that incite constant reactions, interactions, or consumption of content, have brought unprecedented usage of mobile technologies.

In recent years, children's use of technology has become an acute concern. Screen time recommendations from the WHO, The American Academy of Paediatrics, and health ministries in various countries (Gottschalk, 2019) advise no screen exposure for children 0 to 36, 0 to 18 and 0 to 24 months respectively and less than1 hour per day for children 2 to 5 years old. However, a meta-review (36 papers from 15 countries across multiple geographical regions) examining the use of digital devices 49,126 pre-schoolers made, reveals an average 48.34% overuse and 26.83% problematic use (Wang, Qian, Li & Wu, 2023). Similarly, studies in Turkey (Kılıç, Sari, Yucel, Oğuz, Polat, Acoglu, Senel, 2019) on children 0 -5 years old and in the UK (Ofcom, 2021) on children 3-4 years old, report 75.6% and 82% exposure to mobile devices respectively. Children's first encounter with technology was reported to be as early as 6 months old and median age at the first-time use of a mobile device was 12 months (Kılıç, et al. 2019). Device ownership was 30.7% in Turkey and 52% in the UK. Tablets were the most owned device by children with a 68.4% ownership rate in Turkey (Kılıç, et al. 2019) and 48% in the UK (Ofcom, 2021). The use of mobile devices is reported to be predominantly unsupervised and the most frequent activity with mobile devices is watching videos. Extensive use of mobile devices by children happens when parents are undertaking daily tasks and require mechanisms for keeping children entertained and managing behaviour (Kılıç, et al. 2019; Wang, Qian, Li & Wu, 2023).

The evidence on children's use of mobile technologies paints a picture of frivolous unsupervised overexposure at very early stages of development. This evidence fuels concerns over the negative impact of screen-time on children's development and future learning potential. While the usage reported does not represent ML, researchers in the field should not ignore the development cascade risk this poses and the cumulative developmental consequences it may have for children (Masten & Cicchetti, 2010). For instance, screen-time in early years is associated with lower language skills, with difficulties in executive function and attention patterns (Ponti, 2023; Wang, Qian, Li & Wu, 2023). Moreover, screen-time can displace sensorimotor activities needed for motor development (Radesky, Schumacher, Zuckerman, 2015), which is correlated with language and mathematics learning (Bossavit, Arnedillo-Sánchez, 2022).

Against this background we call upon ML researchers to reflect on the consequences the continuous over exposure to mobile devices may have on children's development. We urge our community to engage with stakeholders to produce evidence-based literature, guidelines and policies that will support educators, parents, policy makers and technology corporations to make children-centred decisions based on their well-being and best interest.

8. DISCUSSION

This collective paper resulted in many conversations in which interesting patterns, convergences, and divergences in the issues surfaced. A significant area of tension arose in relation to the ongoing and increasing commodification of education. All agreed that we must maintain a critical perspective on technology and how it is used in education. The growth and interconnectedness of the global economy suggest the necessity for everyone to participate in (inter)national trade which, in turn, has led to a situation in which the acquisition of devices, use of apps, and access to content is the goal. Current devices such as mobile phones and wearables are designed to draw consumers' attention; they are the objects of desire, social status, and participation in society. In post digital terms, they are not yet invisible; rather, they remain highly visible, generating profits for large multinational companies' dependent upon consumers' purchasing patterns. Awareness of the devices and their marketing helps in protecting people. Curiously, the invisible bits and bytes transferred between visible devices via semi-hidden electronic networks support the commodification of people's personal, social, and economic data. As these transactions become increasingly invisible (post digital), powerful corporations can curate, buy, and sell these commodities with little attention or awareness of the end users.

Technology companies now vying for increased market share in education have vested interests in garnering attention, implementing persuasive techniques to control/guide user behaviours, and even foster addiction to their technological products. As technologies appear, they are not only absorbed into people's day-to-day lifestyles but also educational institutions, leading to a situation in which companies modify their marketing messages appealing to educators seeking the panacea to their pedagogical and learning design struggles. As Parsons notes, early ML was enacted with devices capable of text messaging or voice calls. Now, we can choose from a plethora of learning management systems, smartphone applications, wearables, and XR (to name a few), geared for online and face-to-face classrooms. The potential of mobile devices to offer intelligence both for and about learners may, indeed, enhance our ability to design for learning. While the affordances of such technologies are useful and appealing, there is agreement amongst the group that educators must remain aware of both opportunities and risks of technologies, old and new, analogue, and digital. Corporate and government collection of learners' data becomes all that much easier as networks underlying these systems fade into invisibility. As such, learning designers must attend to questions of how learners interact with data, what data they produce, what data they consume, and to what degree they are aware of and can protect their digital footprints.

Inequality of access and ethical use of technology emerged as a significant topic during group discussions of the issues presented in this collective paper. Cristol's contribution highlights the need for access to technology within our globalised economies. Without adequate access to robust technologies, entire communities can be hindered in their efforts to access essential services quickly and efficiently—potentially limiting their ability to participate in important economic and educational activities for achieving a reasonable quality of life. Cristol noted that for those living in digital deserts the notion of 'ubiquitous underlying connectivity' is both a foreign concept and unattainable (unless one argues rather frivolously that the cars they drive are loaded with microchips and therefore represents their participation in the digital sphere). Meanwhile, Arnedillo-Sánchez underscored the potential deleterious effects of unconstrained, overuse of technology in the normal, healthy development of children. While Cristol focused on ensuring access for disenfranchised communities in Ohio to create a 'digital rainforest', Arenedillo-Sanchez warns that access should be considered carefully depending on the people who could potentially be drowned by an ensuing flood.

Almost every author noted artificial intelligence (AI) as both a concern and an opportunity. Parsons suggested that there is a need to "keep ML more human than machine" yet noted that AI could offer contextualised learning for enhanced situated cognition and place-based learning. Rusman looked towards AI as a potential source of solutions for detecting recurring learning design patterns, decision chains, and offering optimal design constellations. MacCallum noted that generative AI could reduce unnecessary repetitive work and allow learners to focus on creativity, ideas, developing deeper understandings, and offer better support for in-situ learning. Meanwhile, Cristol's research suggests that AI remains out of scope for many communities around the world who lack adequate Internet access, and Arnedillo-Sanchez warns scholars to carefully consider how such technologies will impact child/human development. From a post digital perspective, Koole would ask how and to what degree AI will quietly and unnoticeably augment human learning.

9. CONCLUSION

In this paper, we have reflected on the past, present, and future of mobile learning (ML) from different angles and perspectives. We have explored how ML research has been influenced by various social, cultural, and technological changes over the past decades and by different theoretical and pedagogical perspectives. We have also discussed some challenges and opportunities ML faces in different contexts and domains.

Our main argument is that ML is a complex and dynamic phenomenon that requires ongoing reflection and dialogue as well as additional research collaborations among researchers, practitioners, learners, and other stakeholders. We have shown how our collaborative writing process enabled us to share diverse insights into ML and to identify commonalities, divergencies, and tensions among our group. We have also highlighted some areas of future research that could further advance the field of ML.

This collective reflection serves as an invitation for ongoing research and exploration in the realm of ML. We must continue to question, challenge, and refine our understanding through research, always seeking to improve and optimise the educational experiences facilitated by mobile technologies. By combining our efforts, embracing collaboration, and remaining open to diverse perspectives, we can shape a future for ML that is inclusive, innovative, and ethically grounded. As we embark on this journey, let the wisdom of the past guide us, the possibilities of the present, and the aspirations for a future where ML transcends boundaries, empowers learners, and enriches educational landscapes worldwide.

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EVALUATING THE E-ASSESSMENT EXPERIENCES AND DIGITAL LITERACY OF FIRST-YEAR STUDENTS TOWARDS THE DEVELOPMENT OF AN E-ASSESSMENT PLATFORM

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ABSTRACT

The higher education environment is rapidly changing as new technologies continue to appear and be incorporated into teaching and learning practices. The inclusion of e-Assessments is one of the most significant changes in this regard. Compared to conventional assessment methods, e-Assessment platforms offer a more effective and economical alternative to evaluate and assess students. In this exploratory article, the experiences of first-year students towards the development of a new e-Assessment platform were analysed. This qualitative analysis (using both deductive and inductive reasoning) was based on grounded theory and the interpretivism paradigm. The analysis provided insight into students' experiences and how lecturers could improve the e-Assessment experience, present training opportunities, and determine which external factors influenced the learning experience. Most of the students perceived the e-Assessment software as easy to use, with certain benefits compared to the testing functionality of the institution (North-West University) LMS. Connectivity was indicated to be a challenge; however, it is not related to the e-Assessment software, it is currently a general problem (involving external factors such as loadshedding[11]). The negative experience of the e-Assessment platform for students was primarily due to their own levels of digital literacy. Therefore, this analysis of how students experienced the incorporation of a new e-Assessment platform was fundamental in helping academics address the digital literacy and rethinking the e-Assessment journey going forward.

Keywords: digital-based; e-assessment platforms; Cirrus; digital literacy; academic success

1. INTRODUCTION

Technological advances continue to permeate every aspect of the Higher Education (HE) environment. HE institutions (HEIs) have shown a growing interest in developing their respective Learning Management Systems (LMSs) and using high-quality e-Assessment software. Marais et al. (2019:78) argue that this technologically driven era in HE is "defined by its innovative, interactive methods and the promotion of higher education through the emergence of the flipped classroom, a blended learning

[11] Loadshedding refers to routine partial shutdowns to decrease the electricity usage in South Africa.

approach, the use of LMS, a multimodal teaching approach, and e-learning, along with the development of information and communication technologies (ICT)".

The continuous development and implementation of technology pose the question of how students, especially first-year students, respond to the use of innovative technology in teaching and learning. Evaluating students' experiences of digital assessments, as completed on e-Assessment platforms, is of utmost importance. Siddiq et al. (2016) state that e-Assessment platforms provide an efficient and user-friendly way for students to assess their progress and receive teacher feedback. Hussin (2018) and Dhawan (2020) postulate that by using apps, online platforms, and other digital tools, educational institutions are fostering a more personalised learning experience for students while simultaneously streamlining assessment procedures. Although the reliability and validity of e-Assessments are debated, recent research has shown the effectiveness of this software in accurately measuring student progress (Dixson, 2015; West et al., 2016). Furthermore, the e-Assessment software allows greater accessibility, flexibility, and transparency, ultimately benefiting students and educators alike. As such, it is increasingly likely that the continued shift toward including new software as part of the modern classroom experience will be a priority within, HE (Dixson, 2015).

Leinonen et al. (2016), Instefjord and Munthe (2017), as well as Kim (2020) highlight that the importance of students reflecting on their experiences while using digital tools (e-Assessment software, LMSs) cannot be overstated. Reflecting on the efficacy of the specific digital tools they use, students can gain valuable insight into how these tools work, better understand how to leverage the tools in the future and determine their own levels of digital literacy. Fostering a reflective culture among students can also lead to more meaningful learning experiences that maximise individual growth in all academic subjects and broaden educational goals (Martín-Gutiérrez et al*.*, 2017).

The primary objective of this study is to explore the experiences of first-year students in order to implement the Cirrus e-Assessment platform into the North-West University (NWU) LMS. While addressing the primary objective of this study, reference will also be made to the perceived levels of digital literacy of these students and how a greater awareness of the interrelated nature of different modules is necessary for student success. This will add to the ongoing debate, as referred to by Mirzaeva et al. (2020), on the importance and need for transformation, as well as the incorporation and adaptation of digital advances in the South African (SA) HE is teaching and learning environment. This is of importance since the enhanced focus on the inclusion of innovative technological teaching and learning approaches requires students to be digitally literate. The goal is to provide more comprehensive knowledge of the relationship between e-evaluation, digital literacy, and academic achievement and to provide information on how HEIs may better serve students by examining these elements.

2. LITERATURE REVIEW

2.1 e-Assessments

HEIs are embracing the changes and possibilities brought about by the Fourth Industrial Revolution (4IR), and the tipping point was reached in HE when the COVID-19 pandemic forced educational institutions to move to online teaching and learning. In addition to acknowledging the need for (and discussion about) the inclusion of digital literacy into curricula, more SA HEIs are now realising that it is undeniable that the possibilities of a hybrid teaching and learning approach[12] (without the pressure of a pandemic) need to be evaluated and implemented. This refers not only to a renewed focus on the development of LMS content but also to better-structured and designed e-Assessments.

2.1.1 Challenges of e-Assessments in Higher Education

HE now includes computerised evaluation (e-Assessment) as a crucial teaching component, as this provides students and educators with efficient, reliable, and affordable testing options (Arkorful et al., 2015; Irons & Elkington, 2021). To ensure the delivery of high-quality education, a variety of issues have surfaced as the trend toward e-Assessments continues to gain popularity. A main concern is the ability of students to 'cheat' when completing assessments. Herdian et al. (2021) postulate that students have access to a variety of online sites that can help them cheat on exams, which will give them an unfair advantage over their peers. The requirement for a suitable infrastructure to manage the technologies involved in taking tests presents another challenge for e-Assessments. Technical infrastructure, such as reliable internet connections and fully equipped computer rooms, is typically required for digital examinations (Akomolafe & Adesua, 2016). Within the SA HE context, one also must consider the impact of loadshedding and unreliable network reception on the completion of e-Assessments.

Akomolafe and Adesua (2016) argue that for HEIs that serve sizable student populations, establishing and maintaining these infrastructure requirements can be costly and time-consuming. The feasibility and efficacy of e-Assessment are jeopardised in the absence of adequate infrastructure because students may encounter technical issues or have unequal access to digital devices (Akomolafe & Adesua, 2016; Martín-Gutiérrez et al., 2017). Ramu et al. (2022) support this by stating that inclusion is yet another difficulty with using digital evaluations in HE. Some students may be unfamiliar with or have limited access to the resources (digital devices or reliable internet connections) needed to access and complete the e-Assessments. Students of lower socioeconomic origins, those with disabilities and those who attend schools in remote areas where there is little to no access to digital infrastructure are all affected by this problem (Akomolafe & Adesua, 2016).

2.1.2 Benefits of e-Assessment in Higher Education

Henderson et al. (2017) correctly state that traditional assessment methods have been the norm for many years, but that e-Assessments present several benefits that could enhance teaching and learning in HE. According to Henderson et al. (2017), the benefits can be categorized as flexibility, immediate feedback, efficiency, and cost-effectiveness.

[12] Rahman, *et al.* (2018) defines Hybrid learning as "a learning strategy for integrating innovation and technological progress through an online learning system with the interaction and participation of traditional learning strategies".

Henderson et al. (2017) reiterate that e-Assessment offers students more flexibility than traditional assessments, as students can take tests and exams from anywhere in the world, and learning is much more self-directed, paced at a time convenient to the student. The electronic submission of the assessments further reduces the hassle of printing and shipping physical copies. Kumar et al. (2018) adds that immediate feedback to students, through automated grading, helps the students identify areas where they need to improve, ultimately improving their ability to reach learning outcomes. HEI can reduce costs as ~~the~~ e-Assessment reduces the amount of administrative work involved in the grading, reducing the workload of educators (Dumford & Miller, 2018; Limani et al., 2019). Marks (2023:2) adds that e-Assessments also allow educators to use more tools and there is better data management and reporting. Therefore, it is evident that despite the challenges of e-Assessments, one cannot ignore the advantages thereof in HE.

2.2 Digital literacy and HE in South Africa

When considering HE landscapes in the 21st century, it is evident that knowledge acquisition is intertwined with digital competence and digital literacy. According to Zhao et al. (2021:2), digital competence can be defined as "a set of abilities to use technology to optimise our daily lives effectively". The European Commission (2021) indicates that digital competence can be seen as both a social skill and the ability to use technology to gather information for work, entertainment, and education. In its most basic form, digital literacy refers to an individual's ability to send emails, use word processing programmes such as Microsoft Word, and execute basic online data searches (Mohammadyari & Singh, 2015). However, these basic digital literacy skills are no longer sufficient. Students must become competent in a set of transversal skills; they should be able to search, identify, select, and interpret information (simultaneously), be critical about the content, create meaning on a digital platform, all while adhering to cyberspace rules (social-emotional) and realising that navigating these platforms requires individual and social skills (Tinmaz et al., 2022; Vodă et al., 2022). According to Blau et al. (2020), digital literacy should be considered one of the main challenges experienced when integrating technology into teaching and learning.

While digital literacy refers to the ability to navigate the digital environment and the development of information communication and technology literacy (ICTL), academic literacy refers, in the SA HE context, to a support module/service aimed at students' academic acculturation process and can be seen as an intervention to address the development of a range of academic abilities (Alexander et al., 2005; CHE, 2013; Cliff, 2015; McKenna, 2003; Van Dyk et al., 2013). Nel and Janse van Rensburg (2022) refer to these abilities as skills needed to acculturate to the academic environment, transfer knowledge, and move between the different discourse communities successfully, but reiterate that academic literacy does not only refer to language skills, but rather to a multitude of skills. Therefore, the assumption can be made that if students have not yet developed the necessary digital and academic literacy skills, they may not be able to navigate their institutions, and subsequently these students will experience problems when attempting to complete an e-Assessment, whether on the LMS or on an external e-Assessment platform.

An important factor which can be seen as a driving force behind the move towards the inclusion of e-Assessment, and therefore the development of students' digital literacies, is the continuous focus on a hybrid teaching and learning approach, where students and educators are encouraged to embrace the technological advances brought about by the 4IR. Since the dawn of 4IR research, digital skills have become paramount in various disciplines to ensure effective completion of tasks. Therefore, these skills must be developed early in the student's career, highlighting the need to incorporate technology into teaching and learning practices.

2.3 Embracing the digital: Implementing a new e-Assessment platform.

Limani et al. (2019) state that the education is shifting towards a technology-based platform, and e-Assessments have become an integral part of the learning process in HE. e-Assessments offer an efficient and convenient way for educators and students to assess and evaluate student learning outcomes (Benavides et al., 2020). Currently the NWU uses a Sakai-based LMS, through which lecturers have access to a *Test & Quizzes* tool. Developing an assessment with the *Test & Quiz* tool is relatively easy. However, the possibilities and functionalities of this tool are limited compared to other high-quality e-Assessment platforms and/or software available. Van den Berg and Leendertz (2022:134) state that various e-Assessment software tools were evaluated during 2018 and 2019 to identify an assessment tool "which best suits the academic needs and [which] could be seamlessly integrated into the existing LMS". Based on this, Cirrus was identified as the appropriate e-Assessment platform to use for online assessments within the NWU teaching and learning environment. Cirrus boasts an extremely user-friendly interface, allowing assessors (educators) to create formative and summative online assessments.

Cirrus features include the development of question banks (collections), sharing of collections and items (questions) with colleagues, pre-assessment moderation and language editing workflow, and building assessments from the collections (libraries) or blueprint and viewing psychometrics on created assessments (Van den Berg & Leendertz, 2022:135).

The different question types, integrated workflow manager (author, reviewer, editor and moderators), review function of revision history for a set of questions, different taxonomies, learning outcomes and question topics, and assessment data available make Cirrus an exceptional kind of e-Assessment software to use in HE. When comparing the current e-Assessment tool with Cirrus, the assessment possibilities, and options to analyse data-based student results generated by Cirrus are extremely exciting.

In 2021 the pilot phase of the Cirrus implementation into the NWU LMS commenced. As mentioned above, Cirrus is much more complex than the current LMS *Test & Quiz* tool available. This required training[13] of lecturers in the use of Cirrus to ensure a solid understanding of the capabilities and limitations. Lecturers' understanding of the capabilities and limitations of Cirrus and adapting to this

[13] Note that the training of educators to optimally utilise the various functions of an e-Assessment platform can be compared with the digital literacy of students. Both educators and students, therefore, need to be able to access, understand and navigate the e-Assessment software, as would be expected in light of the different roles pertaining to the software (student vs. instructor vs. invigilator).

high-quality assessment platform is not the only factor that influences the success of the implementation; the experience of students when completing assessments is central to the success of Cirrus. In this article, the focus will be on the student experience of this newly implemented e-Assessment platform.

3. METHODOLOGY

The aim of this study was to gain a deeper understanding of the students' experience of the e-Assessment software, Cirrus. The grounded theory design was chosen since its purpose aligns with the intention of generating a new theory (Charmaz & Thornberg, 2021). For this exploratory study, an interpretivism paradigm was followed. The interpretivism paradigm allows researchers to try to understand the world and reality through the experiences undergone (Cohen & Manion, 1994; Yanow & Schwartz-Shea, 2011; Thanh & Thanh, 2015). The analysis is qualitative in nature, following both deductive and inductive reasoning.

3.1 Research population

The research population for this study consists of first-year students from the NWU Mahikeng Campus studying Human Resource Management and Industrial Psychology. These students used Cirrus as their primary e-Assessment platform in their IOPS 111 (Introduction to Industrial Psychology) module. After completing their first two assessments, the students were asked to complete a Google Form (questionnaire) in which they were to rate and share their Cirrus experience. The initial research population consisted of 283 students, but only 189 completed the questionnaire and agreed to participate in this research.

3.2 Data collection

Google Forms was used as a data collection tool (Mayring, 2015). This self-administered and computer-assisted questionnaire provided a simple means of gathering responses. Consequently, this method enriches the thematic analysis by exploring emerging patterns and themes from the students' perspectives.

3.3 Data analysis

The Google Forms questionnaire was based on the experiences of first-year students and their digital literacy competencies in using an e-Assessment platform. This questionnaire had three open questions that measured student experience in three themes, namely challenges, benefits, and training. These three categories, deductively derived from the questions, formed the basis for the analysis. NVivo text analysis software (Birks & Mills, 2015) was used as the primary software for the analysis. NVivo allows thematic analysis by exploring the emerging patterns and themes from the participants' perspectives. ATLAS.ti 23 (ATLAS.ti, 2023) and WordSmith Tools 7 (Scott, 2016) were used as secondary research instruments. To analyse the questionnaire data, the results were exported from the

Google form to a Microsoft Excel document. Data from Microsoft Excel were imported into NVivo, after which qualitative data were reviewed and autocoded[14] (Rogers, 2023; Nowell et al., 2017).

This method involved breaking down the text data into specific themes (deductive themes, as taken from the questionnaire), starting with broad codes, and then narrowing it down to specific categories (inductive process). The key to this approach is to remain flexible and open-minded throughout the coding process, allowing new codes and categories to emerge as needed based on the data. The identified codes were then clustered into categories, which were added to the three main themes. After identifying the categories in NVivo, the researchers used the same approach to code the data in ATLAS.ti 23 and WordSmith Tools 7. The data were analysed using the above-mentioned software to inspect the codes, as well as the context in which the various lexical items were used.

3.4 Ethical Considerations

Ethical approval for this research was obtained from the Research Ethics Committee of the Faculty of Economic and Management Sciences (FEMS) of the NWU, and all research guidelines were adhered to (Ethics number: NWU-00084-21-A4).

4. RESULTS AND DISCUSSION

Each of the three main themes (**benefits** and **challenges** experienced when using Cirrus as an e-Assessment platform and possible **training** for Cirrus) was analysed and will be discussed individually.

4.1 Benefits

The first theme focusses on what participants perceive as a benefit associated with Cirrus use. The autocoding function was used in NVivo to create the codes and subsequent categories. Table 1 shows the results of autocoding in NVivo.

Table 1. Codes and main categories identified: Benefits of Cirrus

Codes	Categories
E-Assessment, easy, digital, complete	Assessment
Internet connection, correct connection, connectivity	Connection
Digital platform, Cirrus platform	Platform

The categories that emerged from the data analysis, as shown in Table 1, are assessment, connection, and platform. These categories are relevant to determine the participants' perceptions of the benefits of using and implementing a new e-Assessment platform. However, based on emerging categories and codes, a word list (including synonyms) was compiled to determine the frequencies of words used to describe the benefits of Cirrus.

[14] Autocoding refers to the automated process of classifying text data into predefined codes or themes based on set criteria (Nowell et al., 2017).

Table 2. Ten words most frequently used to describe the benefits of Cirrus.

Word	Count	Similar Words
easy	61	comfortable, easily, easy, loose, simple
use	46	use, using
saves	30	save, saved, saves, write, writing
time	27	time
see	25	check, encounter, encounters, experience, learn, learning, looking, see, understand, watching
answer	19	answer, answered, answers, responds, results
effective	18	burden, effective, effectiveness, efficiency, efficient, good, issue, issues, results
assessment	17	assess, assessed, assessment, assessments
test	17	exam, test, testing, tests
fast	17	fast, firmly, quick, quickly

From the wordlist, it is evident that the most frequent words all seem positive; however, to validate this hypothesis, a sentiment analysis was conducted. Figure 1 shows the summary of this analysis.

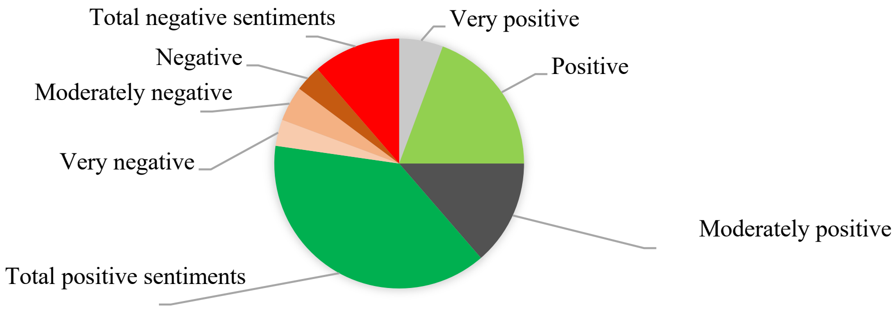

Figure 1. Sentiment analysis of benefits: Positive vs. negative

A final analysis was conducted on ATLAS.ti to determine the context in which positive and negative sentiments were found in the open question pertaining to what students perceived as beneficial when using Cirrus. As is evident from Figure 1, the sentiments in this analysis were mostly positive; refer to Table 3 for a summary of the sentiment analysis, including the responses of the participants.

Table 3: Benefits of Cirrus: Sentiment analysis with text examples

Example	Quote Content: Benefits of Cirrus	Sentiment and Category
ExB1	You can understand how to use online digital platforms	Sentiment: Positive (Platform & Assessment)
ExB2	You get to learn how to use it firmly and be able to answer questions quickly and learn a few concepts you had no idea about	Sentiment: Positive (Platform)
ExB3	Less stressful - easier to use - faster way of testing knowledge. it is easy to access.	Sentiment: Positive (Platform & Assessment)

Example	Quote Content: Benefits of Cirrus	Sentiment and Category
ExB4	It's easy when using cirrus digital assessment	Sentiment: Positive (Platform)
ExB5	The Cirrus digital assessment is easy to understand as it is a straightforward digital platform	Sentiment: Positive (Platform)
ExB6	There cirrus platform is very simple and straightforward	Sentiment: Positive (Platform)
ExB7	the benefit is that you can check your previous answers and check if you picked the correct one	Sentiment: Positive (Platform & Assessment)
ExB8	You are notified if you have mistakenly missed a question.	Sentiment: Positive (Platform & Assessment)
ExB9	Is that when you lose a connection you can easily reconnect	Sentiment: Positive (Connection)
ExB10	Your work is saved if you do encounter any network problems and you could continue where you left off.	Sentiment: Positive (Connection)
ExB11	If you are using a phone it is going to be quite difficult.	Sentiment: Negative
ExB12	It sometime a take a little while to load to another question	Sentiment: Negative (Connection)
ExB13	does take a long time to load and time is set nicely above your eyes it does disturb your unlike eFundi timeline	Sentiment: Negative (Connection)

This analysis indicated that most participants found Cirrus beneficial, especially with respect to the platform and assessment categories (ExB1 to ExB8). The negative sentiments were mostly related to the connection category, which contrasts with the positive experience of other participants (compare ExB9, ExB10, ExB12 and ExB13). It should be noted that some examples, such as ExB13, were coded as negative sentiments, although the participant also added positive feedback regarding Cirrus in the same sentence. In summary, students seem to experience Cirrus as positive. The positive experience is also evident from the ATLAS.ti 23 analysis; see Figure 2.

Figure 2. Benefits of Cirrus: ATLAS.ti word cloud

Figure 2 clearly shows that the words *easy, use* and *time* as most frequently used by participants, further support the finding that most of the participants experience Cirrus as beneficial. Since these first-year students use other e-Assessment software (on the NWU's official LMS), they have an idea of the functionality of other e-Assessment software, and therefore the positive response should be seen as an indication that Cirrus is perceived as a good e-Assessment platform. First-year Human Resource

Management and Industrial Psychology students are therefore mostly in favour of Cirrus, and they were able to identify various functionalities available on the software that can benefit their academic careers.

4.2.1. Challenges

The second theme focusses on what participants perceive as challenges associated with the use of Cirrus. The autocoding function was used in NVivo to create the codes and subsequent categories. Table 4 shows the results of autocoding in NVivo.

Table 4. Codes and main categories identified: Challenges experienced with Cirrus.

Codes	Categories
Internet connection, good network connection, connectivity problems, and bad network connectivity	Connectivity
Online assessment, e-Assessment, and Cirrus assessment	Assessment
Vocational exam network, unstable network, good network connection, network issues, bad network	Network
Wi-Fi problems, connectivity problems, endless problems	Problem
Connectivity issues and network issues	Issues
Different options and little opinion	Opinions
System notification	Systems
Enough time, time duration, time consuming and sufficient time	Time
Challenges none, far none, and questions none.	None

Based on emerging categories and codes, a word list (including synonyms) was compiled to determine the most frequent words used to describe the challenges encountered on Cirrus.

Table 5. 10 words most frequently used to describe the challenges of [the circulus? Cirrus]

Word	Count	Similar Words
experience	80	experience, experienced, feel, get, living, see
challenges	76	challenge, challenges
connectivity	58	connect, connection, connectivity
assessment	54	assessment, evaluation
network	44	network
questions	44	questions
answer	42	answer, answering, answers
needs	40	motivation, needs, require, requires, takes
use	36	use, using
problems	34	problem, problems

The most frequent words (as depicted in Table 5) seem to correspond to the categories and codes presented in Table 4. The high frequency of the words *challenges* and *experiences* can contribute to the nature of the question. To determine whether the general sentiment of these words can be seen as negative and to corroborate the findings presented in Tables 4 and 5, a sentiment analysis was performed. Figure 3 shows the summary of this analysis.

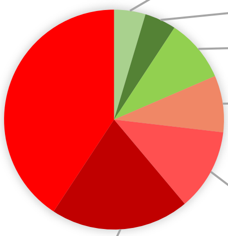

Figure 3. Sentiment analysis of challenges: Positive vs. negative

A final analysis was conducted on ATLAS.ti to determine the context in which positive and negative sentiments were found.

Table 6: Challenges of Cirrus: Sentiment analysis with text examples

Example	Quotation Content: Benefits of Cirrus	Sentiment and Category
ExC1	When you have accidentally clicked the next but even if you haven't attempted to answer	Sentiment: Negative (Assessment, Problem, Issue & System)
ExC2	The negatives are; once you lose internet connection, you cannot proceed with the assessment until your device is reconnected	Sentiment: Negative (Assessment, Problem, Issue & System)
ExC3	Network issues since we are living with load shedding it is difficult to connect or get best connection about network.	Sentiment: Negative (Assessment, Problem, Issue & System)
ExC4	Is that when you lose a connection you can easily reconnect	Sentiment: Positive (System)
ExC5	you must keep up with the time allocated	Sentiment: Negative (Time)
ExC6	I feel like this cirrus assessment thing is confusing us because it marks for us while we are answering, and we do have different opinions and views unlike if it was the lecture marking	Sentiment: Negative (Opinion, Assessment & System)
ExC7	I haven't encountered any challenges thus far as it was my first-time using Cirrus e-Assessment	Sentiment: Positive (System & Assessment)
ExC8	Can't complete the sentence without the system notification popping up and distracting you	Sentiment: Negative (System, Time & Assessment)
ExC9	network can disturb you	Sentiment: Negative (Connectivity)
ExC10	navigation of cirrus	Sentiment: Negative (System)
ExC11	It's online and there may be many challenges such connectivity problems and some users lack the skills to navigate a digital assessment	Sentiment: Negative (Issue, System, Connectivity, Assessment & Problem)

Example	Quotation Content: Benefits of Cirrus	Sentiment and Category
ExC12	I see no challenges unless I experience loadshedding during the exam	Sentiment: Positive (Issue, Problem, Connectivity)
ExC13	For me there are no challenges but the negatives for others can be that they may experience Wi-Fi problems	Sentiment: Positive (Issue, Problem, Connectivity)

When comparing the responses to challenges to the benefits, it seems that several participants indicated that network and connectivity was challenging (see ExC2, ExC3, ExC9 and ExC11); however, returning to the assessment and continuing where one left off was noted being among the benefits of Cirrus (see also ExB9, ExB10, ExB12, and ExB13). Furthermore, the reference to loadshedding and connectivity challenges should be noted as external factors influencing students' experience of Cirrus. ExC1, ExC5, ExC6 and ExC8 are once again not related to Cirrus. Difficulties in answering and/or understanding questions refer to a student's inability to read with comprehension and to analyse the task at hand, and time concerns can be attributed to inadequate reading speed, skills that are developed in the academic literacy module[15]. Therefore, these challenges are more related to the academic and digital literacy skills of the students. The ExC11 example is quite interesting, as this participant added to the argument that digital literacy influences the Cirrus experience (this response was coded as negative, while it is, in fact, a very insightful and positive response). Similar analysis was carried out in the previous section; a word cloud was created to summarise the findings in this section.

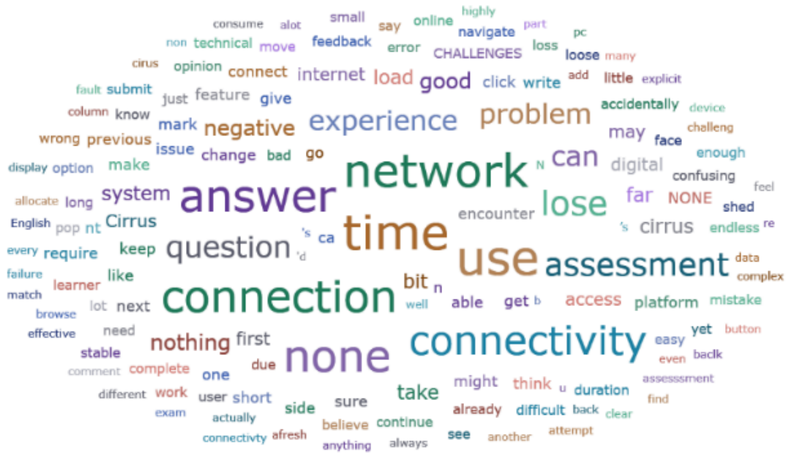

Figure 4. Challenges of Cirrus: ATLAS.ti word cloud

Despite the challenges noted, the conclusion can be made that most of the challenges experienced with Cirrus relate to external issues (time concerns, formal (difficult) language, experiencing difficulties in understanding how to navigate Cirrus) and not to the usability of Cirrus. Most of these challenges can be eliminated through the development of digital (and academic) literacy skills, as well as something as simple as keeping the loadshedding schedule in mind when completing assessments.

[15] At the time of this questionnaire students were still in the process of completing the first of two Academic Literacy modules, and therefore their reading and comprehension skills ~~should~~ would be expected to improve towards the end of the academic year.

4.3. Training

The last theme analysed in the questionnaire was the perception of the training needed. From the NVivo analysis, various codes were identified, which have been grouped together as training needs as perceived by the participants.

Table 7. Themes and subthemes identified related to the training needs for Cirrus.

Codes	Categories
Tutorial videos, quick video tutorial, educational videos, conducting videos, video introduction	Videos
Tutorial videos, online tutorial, quick video tutorial	Tutorial
Computer lab, computer skill course	Computer
Taking tests, especially tests	Tests
Short courses, computer skill course	Courses
Online tutorial	Online tutorial

The training needs, as presented in Table 7, show quite a few overlapping needs. Based on emerging categories and codes, a word list (including synonyms) was compiled to determine the most frequent words used to describe Cirrus training needs.

Table 8. 10 words most frequently used to describe the training needs of ~~the~~ Cirrus.

Word	Count	Similar Words
use	53	practice, use, used, using
cirrus	35	Cirrus
training	31	check, directed, educational, school, schools, take, taking, train, trained, training
students	28	student, students
get	27	experience, get, gets, let, make, making, start, take, taking
online	25	online
tests	22	quiz, quizzes, test, tests
teach	21	educational, instruction, instructions, learn, learning, teach, teaching
making	21	Clear? create, form, give, gives, giving, make, making, take, taking, work, works
video	19	video, videos

Once again, the most frequent words seem to concur with the categories and codes presented in Table 7. Further analyses were conducted in ATLAS.ti to determine the exact nature of the training needs[16].

[16]At the time of this questionnaire students were still in the process of completing the first of two Academic Literacy modules, and therefore their reading and comprehension skills would be expected to improve towards the end of the academic year.

Table 9: Cirrus Training Needs: Examples from participants

Example	Quotation Content: Training needs for Cirrus	Category
ExT1	*Computer lessons* by tutorial *videos*	Tutorial, Courses & Online tutorial
ExT2	sharing educational videos on Efundi to easily learn via the video	Video, Tutorial & Online tutorial
ExT3	they can only follow the steps and read the steps that must be taken to start the assessment on cirrus.	Tutorial & Online tutorial
ExT4	BY MAKING PRACTICE TEST AND LET THEM USE THE CIRRUS	Tutorial, Test & Online tutorial
ExT5	By using Efundi platform as a guideline for better understanding of Cirrus	Tutorial & Online tutorial
ExT6	One on one training *videos or tutorials*	Tutorial, Video & Online tutorial
ExT7	I feel like training is not really needed because it is very much easy to use.	Tutorial & Online tutorial
ExT8	there should be *online* training *Learning* by *exposure*	Tutorial & Online tutorial
ExT9	- they will eventually get it. *Contact* training must be provided	Training
ExT10	done it *online* Ranking students to computer *lab* By showing them the steps they need	Training

Based on categories, wordlist, and response examples, it seems that there is a definite need for training. Furthermore, it is evident that the participants do not have a problem with Cirrus, but rather with their digital and literacy abilities. Some students asked for a computer literacy course, a course that is included in their academic literacy module, therefore supporting the initial premises that students do not realise the interconnectedness of their various modules. Figure 5 supports the conclusion reached in the analyses and clearly represents the training needs of the students (resource type and mode of delivery).

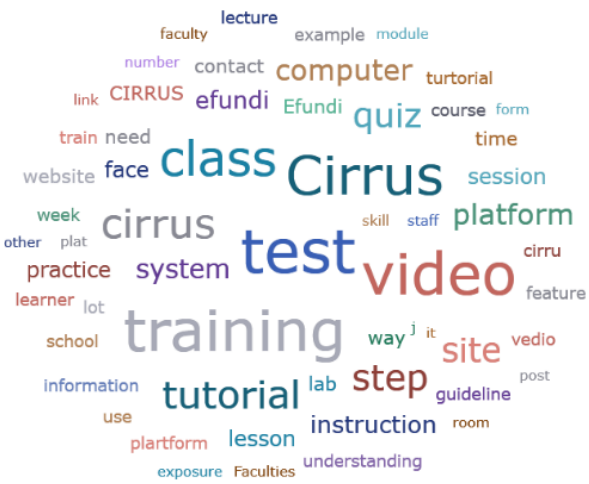

Figure 5. Word cloud depicting the need for training.

Based on this analysis, a roadmap was created as an exploratory guideline to improve the student experience with Cirrus. The first theme, identifying challenges when using Cirrus, led to the identification of five categories that need to be addressed to ensure student success: opinions, problems, issues, networks, systems, and connectivity. The second theme of the roadmap is to provide and facilitate the need for training in digital assessments, as identified by the students. These needs are represented by the themes of videos, tutorials, online tutorials, courses, computers, and tests as indicated by the students. The final theme in the roadmap is to evaluate and communicate the benefits of using e-Assessments to enable and allow the adoption of digital transformation in higher education. Each of these themes can help lecturers better equip students to understand and use e-Assessment platforms, ultimately contributing to student success. Regarding the challenges, lecturers can now address possible issues experienced by students before conducting tests on e-Assessment platforms and mitigate the risks by developing the skills needed to navigate such a platform. The benefits of this e-Assessment platform, as experienced by the students, can be used to demonstrate the effectiveness and impact of the e-learning assessments, and to foster or improve student engagement and satisfaction with the e-learning assessments. Figure 6 refers to a roadmap created to summarise the findings of this article.

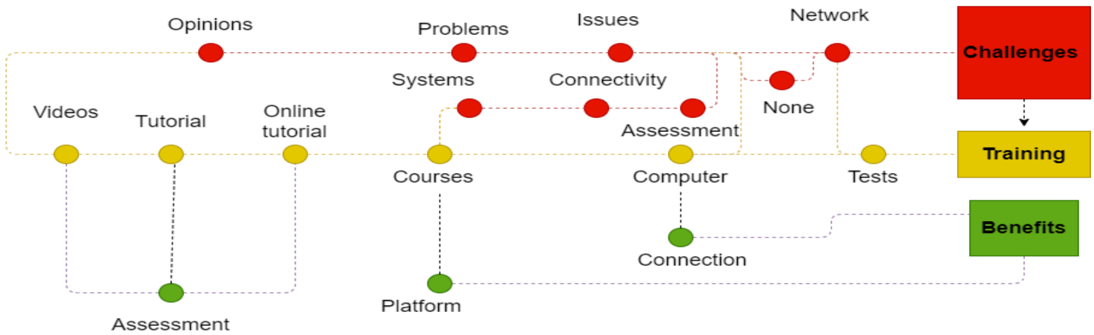

Figure 5: Successful e-Assessments: A roadmap for Cirrus

5. CONCLUSION

The primary objective of this study was to explore the experience of first-year students with Cirrus implementation of the e-Assessment software in the North-West University LMS. While addressing the primary objective of this study, references were also made to the perceived literacy levels of these students and how greater awareness of the interrelated nature of different modules is necessary for student success.

The data collected from the questionnaire were divided into three main themes for analysis (benefits, challenges, and training needs). The analysis of these three themes was performed in NVivo, WordSmith Tools 7, and ATLAS.ti 23. Regarding the primary aim, it can be concluded that the overall experience of Cirrus as e-Assessment software, as used by first-year Human Resources Management and Industrial Psychology students, is positive.

The first theme analysed was the benefits experienced by the students when using Cirrus. The overall response was positive, and, in this regard, all evidence points towards Cirrus as being experienced as beneficial and that the overall attitude towards this e-Assessment software is positive. The second theme analysed was the challenges experienced by the students when using Cirrus. Given the nature of this group of questions, it was anticipated that the students' experience of Cirrus would be documented ~~to be~~ as much more negative. However, the main identified challenge was connectivity. Upon further investigation, it became evident that connectivity (when excluding external factors such as loadshedding) was perceived as positive in Cirrus, as most of the participants indicated that they continued with their assessment after restoring their connectivity without losing any progress. After conducting the WordSmith Tools 7, and ATLAS.ti 23 analyses, it became evident that most of the challenges mentioned by the students were related to external factors and were not related to Cirrus useability.

The biggest issues, such as time concerns, formal (difficult) language, and experiencing difficulties in understanding how to navigate Cirrus refer to issues related to academic literacy and digital literacy levels and not to the usability of Cirrus. This finding speaks to the secondary aim of this study, which was to show? the levels of digital literacy of these students and how greater awareness of the interrelated nature of different modules is necessary for student success. Therefore, regarding the second theme analysed, it can be concluded that, based on the student's experience, navigating, and completing assessments on Cirrus do not pose many challenges. However, the finding did indicate that these students' digital and academic literacy are not yet satisfactory, and that the absence of these skills has an influence on the students' perception of e-Assessment software.

The final theme analysed was the training needs perceived by the students after using Cirrus. From this analysis, once again, answers relating to the primary and secondary objectives of this article were identified. Regarding the students' perception of Cirrus and their perceived training needs, students will benefit from video tutorials explaining the basic functionalities of Cirrus. However, the general attitude towards training was that it is unnecessary and that the more time students spend on Cirrus, the more comfortable they will become in using the software. It was also determined that, based on the training needs of some students, they do not realise the interconnectedness of their various modules. Some of the training requests included a computer literacy course, a course that is offered in their academic literacy module.

When comparing the findings with the literature study conducted, we can assert that when exploring the point of view of first-year students toward the implementation of the e-Assessment software in NWU LMS, we identified the same issues as mentioned in the literature. This is also true when analysing the academic and digital literacy levels of these students.

Although e-Assessments offer numerous benefits, it remains essential to maintain general academic integrity and provide high-quality assessments. To enhance the advantages of e-Assessments in Higher Education, institutions and educators must address the challenges of dishonesty (cheating in assessments), create the necessary infrastructure, ensure inclusion by making students aware of the interconnectedness of their various modules and emphasise the necessity of academic and digital literacy. e-Assessments can continue to evolve to meet the demands of a changing educational environment through innovation and ongoing improvement.

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BOOK WIDGETS AS A GAMIFICATION TOOL TO SUPPORT TEACHING AND LEARNING

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ABSTRACT

Gamification has played a significant role in the education environment and has been gradually integrated into teaching and learning. This integration has led to increased efficiency, motivation, and learner engagement, which supports learner success. Book Widgets is a content creation tool that teachers can use to create interactive and engaging content. The Book Widgets application can be used as a gamification tool to support teaching and learning. This study explored Book Widgets as a gamification tool to support teaching and learning by investigating the gamification elements and how they promote learner motivation, engagement, and participation. The gamification taxonomy was used as a theoretical lens for the study. This study was conducted using the interpretivist paradigm, with a qualitative approach and the use of a case study design to collect rich data. A sample of ten (10) Grade 5 students were selected using non-probability sampling. Semi-structured interviews were conducted with 12 open-ended questions to collect data. A thematic analysis highlighted the elements which were reported on using the gamification taxonomy as a structuring principle. Gamification mechanisms, such as bonus points and progress bars enhanced engagement and motivation. Results show that the Book Widget application promotes motivation as students enjoy completing the activities and describe it as fun. Students are actively engaged and want to participate in the activities as they feel like they are playing a game and forget that they are learning.

Keywords: gamification; Book Widgets; gamification taxonomy; teaching and learning

1. INTRODUCTION

The main issue in modern education as identified by Kiryakova et al. (2017), is the lack of engagement and motivation of students to participate actively in the educational process. As a result, educational games can be used in the classroom to deliver educational content; many studies have been conducted examining how games can contribute to the learning process (Dichev & Dicheva, 2017; Knutas et al., 2014; Vlachopoulos & Makri, 2017). According to Soflano et al. (2015), game-based learning, serious games, and gamification have become prominent research concerns. Gamification is often misunderstood since game-based learning, serious games, and gamification are intertwined

(Armstrong & Landers, 2018), despite the differences in principles and concepts between them. As a result, gamification can easily be confused with game-based learning or serious games. Therefore, there have been numerous approaches in the literature to define the concept of gamification. Kapp (2012) describes gamification as the process of improving students' learning and problem-solving abilities using game-based mechanics and game-thinking approaches. Alternatively, Deterding et al. (2011) have defined 'gamification' as using elements and techniques of game design in a non-gaming environment. As demonstrated, gamification, which involves the use of game elements and techniques in non-game environments, can increase motivation and enhance engagement and participation in learning environments (Muangsrinoon & Boonbrahm, 2019). As part of the gamification process, points, badges, leader boards, and incentives are used to increase engagement and participation. Additionally, gamification involves the use of game elements to motivate students to achieve their learning objectives (Findlay, 2016). Many studies have demonstrated the effectiveness of gamification; however, there has been relatively little research conducted regarding how gamification elements may motivate students and promote engagement and participation, which remains a significant challenge in modern learning environments (Hanus & Fox 2015; Uz Bilgin & Gul, 2019). As a result, this study aims to explore Book Widgets as a gamification tool to support teaching and learning by investigating the gamification elements and how they promote student motivation, engagement, and participation.

2. LITERATURE REVIEW

Gamification encompasses a variety of components. As proposed by Bunchball (2010), gamification can be divided into two components: dynamics and mechanics. The gamification concepts and elements that are included in both frameworks are similar, despite their terminologies and approaches. Mechanics refers to the components of gamification that determine the rules, procedures, and algorithms of the game. Furthermore, Badges, Points, Leader boards, Levels, and Challenges are among the most used motivators for students (Hamari et al. 2014). In contrast, dynamics are abstract ideas that arise from the interaction between students and game mechanics. Examples of these dynamics include achievement, competition, status, and progress monitoring (Uz Bilgin & Gul, 2019).

Using gamification components of dynamics and mechanics, gamification aims to elevate intrinsic and extrinsic motivations through games and game-like approaches, in order to motivate students and enhance engagement and participation. The intrinsic motivation method involves the use of blending ideas and elements to create a more engaging experience for students, whereas the extrinsic motivation method involves the use of game elements, such as points and leader boards to enhance the learning experience (Marczewski, 2017). To motivate students intrinsically or extrinsically through gamification, teaching and learning activities can be gamified by incorporating some gaming elements into the existing curriculum (Wang et al., 2021). When gamification elements are incorporated into teaching and learning, students are likely to be more engaged and motivated to participate in the subject matter, resulting in greater concentration levels as well as greater engagement and participation in the activity (Furdu et al., 2017; Landers et al., 2017). Therefore, gamification elements are employed in educational environments to enhance the learning process.

Domínguez et al. (2013) report that several gamification mechanisms are being used to engage students in the classroom, including rewards, challenges, points, badges, and leader boards. With these gamification elements, learning will become more enjoyable and engaging, increasing engagement and participation. Consequently, students' learning experiences are greatly enhanced when they are motivated and engaged. The integration of gamification elements in teaching practices has the potential to boost teachers' confidence by improving engagement and participation in the classroom (Ghavifekr et al., 2016). Therefore, gamification in a non-gaming context can lead to improved student engagement and learner motivation (Werbach, 2014) in education. Further, by using appropriate gaming elements, students can achieve desired educational outcomes (Mee Mee et al., 2020).

Gamification has been used in various educational settings to increase student engagement and motivation (Dichev & Dicheva 2017). Teachers have found Google Classroom and Book Widgets (www.bookwidgets.com/) to be extremely useful for motivating students to participate in the learning process. Sukmawati and Nensia, (2019) describe Google Classroom as a free, cloud-based platform for creating, distributing, and grading assignments in educational institutions. The primary objective of Google Classroom is to facilitate the sharing of files between teachers and students (productforums.google.com). Book Widgets, on the other hand, is an exceptional tool for educators and curriculum developers as it provides them with an array of interactive content. Content can be shared in a variety of formats with students, and comprehensive analytics on student performance are also provided (Karlin, 2016). While Google Classroom was originally designed to facilitate communication between students and teachers, Book Widgets have gained popularity due to their compatibility with Google Classroom, Canvas, Moodle, digital whiteboards, and other electronic devices (Daily, 2020). As Book Widgets are compatible with Google Classroom, the application is far more effective at motivating students to learn, as well as promoting engagement and participation in the learning environment. Moreover, since Book Widgets is cross-platform, it can run on any device, regardless of its operating system, ensuring that users have easy access to content no matter where they are (Renard, 2020). The Book Widgets platform provides easy-to-use tools for creating interactive activities, including games, such as crossword riddles, bingo sheets, and memory games. Using the memory game widget, Buckinx (2020) demonstrates that recognising a pair of terms offers a better representation of their relationship than simply memorising them. Several assessment activities are graded automatically, and instructions are provided for completing each assessment, allowing teachers to monitor student progress in real time. Among the several activities offered by Book Widgets, storytelling tools can be used along with seven different applications to keep students entertained (Tronçon, 2023).

The most important mechanisms of the Book Widget application are rewards, badges, points, and level systems. As a result of analysing these elements, other gamification mechanisms are evident, such as reward systems when a certain level is reached, which are currency earned by completing tasks. Using interactive exercises, gamification technologies, such as Book Widgets, are being used in educational institutions to enhance learning. With Book Widgets, learning needs can be met and formative and summative assessments can be conducted (Flores, 2015). The recognition and choice of gamification elements in gamified environments are not trivial tasks, however, some frameworks aim to simplify the process.

Various researchers aimed to create gamification taxonomies for using gamification in their specific environments. For example, Robinson and Belloti (2013) created a complex and detailed Taxonomy of Gamification Elements categorising different levels of commitment, based on the findings of their research. They divided their framework into General framing, General rules and performance framing, social feature, Intrinsic and Extrinsic incentives, Resources and constraints, and Feedback and status information. In addition, Obaid et al., (2020) created their gamification taxonomy based on the gaming elements and ended up with achievements, micro interactions, story, personalisation, time, and reward. Like the work of Obaid et al. (2020), Toda, Oliveira, Klock et al. (2019) developed a gamification taxonomy, but focuses on the gamification elements as opposed to Obaid et al. (2020) gaming and Robinson and Belloti's (2013) preliminary taxonomy. Therefore, this study adapted the gamification taxonomy of Toda, Klock et al. (2019) to investigate the gamification elements of Book Widgets. The gamification taxonomy framework Toda, Klock et al. (2019) describes key dimensions in which gamification takes place. The gamification elements present in the Book Widgets application were identified and categorised according to dimensions and elements of the gamification taxonomy framework.

The **ecological** dimension includes elements such as chance, imposed choice, economy, rarity (Dignan, 2011), and time pressure Toda, Oliveira, Shi et al. (2019). The ecological elements make the environment interactive. Book Widgets provides students with several rewards, such as badges and points, that facilitate extrinsic motivation Toda, Klock et al. (2019). A reward programme encourages and endorses students' efforts, which improves their performance (https://www.bookwidgets.com/).

In the **social** dimension, elements include competition, cooperation, reputation, and social pressure. When these key social elements are not available in the environment, the interaction between students becomes difficult (Toda, Oliveira, Klock et al., 2019). Book Widgets contain gamification mechanisms such as points, scoring, ranks, progressive achievement, social interaction, rewards, and teamwork to facilitate the social dimension.

The **personal** dimension includes elements such as novelty, objective, puzzle, renovation, and sensation. When personal elements are unavailable in the environment, students become demotivated from participating (Toda, Oliveira, Klock et al., 2019). Book Widgets contain elements of the personal dimension as the site is visually appealing through sensation, uses puzzles, flashcards, and the addition of new content, enabling the user to gain a clear objective when learning languages through gameplay (Toda, Oliveira, Klock et al., 2019).

The **fictional** dimension focuses on the experiences that create imagination or fiction. The elements of the fictional dimension include narrative and storytelling (Toda, Oliveira, Klock et al., 2019). Book Widgets offer a variety of ways for students to remember stories or gain knowledge about the information contained within them. The narrative element involves implicit decisions that stimulate intrinsic motivation. Through the order of events within the game, the students' imagination is stimulated (Toledo Palomino et al., 2019). As students find creative solutions to the challenges presented in the game, they become increasingly engaged in the narrative (Renard, 2020). As part of storytelling, text or audio stories are used to stimulate students' intrinsic motivation in certain environments. Storytelling relies on text and voice (Toledo Palomino et al., 2019).

Performance dimension is related to the environmental response, which provides feedback to the learner through assessment of progress and level. The elements of the performance dimension include acknowledgment, level, progression, points, and stats (Toda, Oliveira, Klock et al., 2019). Mechanisms such as progress bars and feedback are displayed in the Book Widget application to indicate performance. In the Book Widgets application, progress bars have the potential to motivate students who are falling behind in their academic progress (Raymer, 2011), while points and feedback motivate them to try again.

3. METHODOLOGY

The study adopted a qualitative approach in conjunction with a case study design to obtain in-depth information. By employing a qualitative approach, the researcher gained insights into the lived experiences, perceptions, and views of the subjects (Merriam & Tisdell, 2009). Using a case study design, this study offered insight into ways in which gamification can support student learning. In this study, participants were from the same school, hence the researcher was able to gather factual and primary information about Book Widgets.

A sample of ten (10) female Grade 5 students from a private school in Riyadh, Saudi Arabia, agreed to participate in this study. The ethical issues considered, include informed consent, confidentiality, voluntary participation, and protection of participants. In this study, ethical procedures followed the University of Pretoria policies and the Protection of Personal Information (POPi) Act, and school permission was obtained. As the students were minors, consent forms were signed by their parents and assent forms were signed by the students giving their consent to participate in the study. Since the Saudi Arabian school year begins in August and ends in June, data was collected during December, when school is at its peak.

Based on information gathered, the sample was deemed adequate to describe how gamification elements were integrated into the classroom for teaching and learning using Book Widgets. Using semi-structured interviews, the researcher asked open-ended and probing questions to gather qualitative data on participants' responses (Adams, 2015). Atlas.ti software version 2015 was used to perform an inductive thematic analysis to classify responses according to the elements of the gamification taxonomy framework.

4. FINDINGS

The Book Widgets application was explored to identify how gaming elements support teaching and learning. The findings of this study are presented using the gamification taxonomy as a structuring principle to code the data according to the dimensions in the gamification taxonomy. The data is discussed in terms of the elements as a subset of the broader dimensions within the gamification taxonomy. Quotes from participants are used to support the researchers' interpretation of the data relative to the elements and dimensions in which they are classified. For the purposes of this article, participant responses will be reported on using pseudonyms (participant 1-10). Elements will be emphasised in bold and italics for easy readability.

4.1. Ecological dimension

In the ecological dimension, elements such as ***chance*** are highlighted when students received bonus points because of chance. Participant 5 claims, *"…I feel excited to play games on Book Widget to learn more and get higher points",* emphasising the effect of bonus points on motivating student learning. Usually, points, badges, medals, or awards are seen as part of the acknowledgement element under the performance dimension, however, in this case bonus points were awarded to students for demonstrating excellence in their work, or for effort beyond what was expected. Therefore, in this instance, bonus points were not awarded by randomness, luck, probability, or fortune (Ortiz-Rojas et al., 2019) but rather stimulated the students intrinsically as incentives to motivate them to work harder and try their best.

Participant 3 mentioned *"I work hard just because I just want to earn more bonus points",* thus, earning ***bonus points*** contributes to students' motivation to work hard in order to earn extra points.

The role of ecological dimension is highlighted when Participant 3 mentioned, *"I am motivated to complete the task because I want to be on time.",* showing ***time pressure*** as another element that motivated students to use the Book Widgets application. The student sees the deadline for completing the task as extrinsic motivation (Toda, Oliveira, Shi et al. (2019). However, participant 2 mentions, "*If I do not finish or time up, I feel sad, and defeated,"* suggesting a sense of demotivation when losing (Daugherty & MacLin, 2007).

The overall effect of this dimension is to stimulate both intrinsic and extrinsic motivation, which are expressed in different ways. The bonus points, in this instance, were awarded to students based on the probability of progressing well or exceeding expectations in terms of their efforts. It is therefore perceived that bonus points awarded in Book Widgets are part of the chance element since they are meant as incentives to motivate students to work harder and to do their best. Bonus points have been observed to stimulate students intrinsically and contributed to their interest in the activity (Ryan & Deci, 2000). Time is often used as an external motivator in games to pressure students. Students perceive the deadline for completing the task as an extrinsic motivator. Moreover, intrinsic motivation is more likely to cause long-term, sustainable engagement than extrinsic motivation (Liu et al., 2019). Thus, bonus points can be a powerful tool for engaging students, while time-based pressure can motivate students to complete tasks quickly, however, is limited in its long-term effect.

4.2. Social dimension

Many of the participants were disappointed when they scored lower than their peers or lost a game. Since the book widget application provides scoreboards, it motivates students to participate as well as encourages them to succeed through social pressure (Dicheva et al., 2015). The disappointment the students felt relates to the ***competition*** element as Participant 5 claims, *"It looks like a competition and in a competition, I really want to win, so then I'll actually try my best."* As the Book Widget application allows students to form teams and encourages them to work together to accomplish a task (Dicheva et al., 2015), students mention "*playing with friends*" (Participant 6) as fun and motivating, alluding to the element of ***cooperation***. Providing students with their summary results instils a sense of competition since they can see that they did not achieve 5/5, hence, they are motivated intrinsically to achieve better results.

Elements of ***reputation*** and ***social pressures*** also play a role in the social dimension and are both identified in the response of participant 8.

> *"Yes. It like keeps me motivated and seeing who will win... it encourages me more that she can do this, I can do that so we can see if she is winning, or I am winning."* (Participant 8)

Reputation is shown in students' responses to wanting to reflect their skills by achieving certain levels and reaching a certain status within the game (Toda, Oliveira, Klock et al., 2019). The social interaction between the students compels them to achieve a particular goal due to peer pressure, thus stimulating intrinsic motivation (Toda, Oliveira, Klock et al., 2019).

During the social dimension, extrinsic motivation is stimulated when students want to compete to achieve higher goals (Toda, Oliveira, Klock et al., 2019). Intrinsic motivation, on the other hand, is developed when students collaborate to accomplish a certain goal (Shi et al., 2014).

4.3. Personal dimension

Participants mention that the new features, animations, colours, and background sounds encouraged them to learn. As mentioned by Participant 6,

> *"Animations make me want to learn more because it makes the game so fun and, and so good… Yeah, because the games are fun…the colours, clips and the music is so relaxing. "*(Participant 6)

This relates to the element of ***sensation*** which stimulates senses for intrinsic motivation (Toda, Oliveira, Klock et al., 2019). Participant 8 goes on to mention how the "*Colours encourages me to learn more and get my attention…colours look good and beautiful to me."* This highlights how colours grab and keep the attention of students to extrinsically motivate them to continue (Poulsen et al., 2008).

Renovation describes aspects that motivate students on an intrinsic level to attempt a second opportunity (either redo or receive a second life) if they fail (Lee & Hammer, 2011) as indicated by participant 9, *"I would try again. If I got less again, I would study, then try again… It motivates me.*

Book Widgets makes me want to learn more." Therefore, students indicated that Book Widgets motivates them on an intrinsic level, to learn more, given a second opportunity.

Moreover, Book Widgets allows for the presentation of new and emerging content (***novelty***) with regular updates. The release of new features has allowed Book Widgets to become an incredibly powerful educational tool, allowing teachers to provide their students with more engaging learning opportunities (Renard, 2022).

According to participant 7, after experiencing the new design features on Book Widgets, *"... makes it more fun and, uh, it makes like, it makes me more motivated"* while Participant 5 goes on to mention that "*...it does encourage me to keep on learning because you can use it. Um, Book Widgets in any application like Google Classroom and Canvas"*. Participants emphasised the user friendliness and accessibility of the changes in the application and agree with Hanus and Fox (2015) who highlighted that Book Widget users are more likely to be engaged when they are presented with new information and content.

When using Book Widgets, students received ***puzzles*** by using quizzes or challenges in the learning environment as cognitive tasks (Toda, Oliveira, Klock et al., 2019). The participants highlighted the effectiveness of the quiz in Book Widgets as motivating them to learn. According to participant 1, *"Quiz keeps me focused… it is more like a game than like a quiz or something. So, I try to get, get better and better every time."* This suggests that quizzes help students to learn better and motivate them to finish tasks quicker. This is supported by participant 4 who said, *"It makes me more excited to finish the task faster on a quiz."*

The ***puzzle*** element and the time pressure element are described in the ecological dimension work collectively to motivate and engage students. According to participant 1, *"Quiz keeps me focused… it is more like a game than like a quiz or something. So, I try to get, get better and better every time."* The participant highlighted the role of the quiz in a form of a crossword puzzle within Book Widgets, as motivating students to learn. This emphasises that quizzes (puzzles) motivate students to learn more and strive to accomplish the tasks before the timer expires.

The intrinsic motivation of a student is directly related to the individual's personal interest or enjoyment of the task at hand (Ryan & Deci, 2000). A combination of animations, colours, background sounds, new design features, quizzes, and challenges stimulated participants' intrinsic motivation. As a result of these features, students found the tasks more enjoyable and engaging, as well as a sense of accomplishment upon completing them.

4.4. Fictional dimension

Using the Book Widget application, students acknowledge the audiobook as a ***storytelling*** mechanism. As explained by Participant 2, "*Well, audiobook explain to me how, and what tasks on Book Widget means before I complete the task."* Audio plays an integral part in storytelling, as students need to use their imagination and it stimulates students' intrinsic motivation (Toledo Palomino et al., 2019). The imagination and fun that the students experienced is evident when Participant 9 describes, "*Book Widget is fun and encouraging…it does not feel like school",* emphasising how students get immersed into the game (Ahmed & Sutton, 2017) and they are not consciously aware that they are learning.

As a result of the audiobooks, students were able to unleash their imagination and acquire an intrinsic motivation to learn, which enhanced their experience and made the games more enjoyable. The students were more engaged in the learning process. In addition, Book Widgets collaborates with seven different storytelling tools that provide students with an immersive and interactive learning environment that keeps them motivated and engaged (Knapen, 2020).

4.5. Performance dimension

The ***acknowledgement*** element played a big role in the Book Widgets application as it was often also linked to other elements contributing to motivation. Badges, level advancement, progress bars, and points were all mentioned as components of acknowledgement. These components are seen as an extrinsic feedback mechanism to commend a player's specific actions (Toda et al., 2018). Participant 10 mentions receiving bonus points, "*I feel happy because when you earn bonus points it's like feels like you're getting like you like did something that's extra and you get like a like a present word."* This implies a sense of reward. In addition, Participant 5 also mentioned that ***points*** made them "*feel excited, um, to play, um, to learn more and play more, cuz then I can get higher points*."

Participant 3 describes that, *"Progress bar motivates me because I would fail in the first time, and second time, maybe better the third time…. It will help me to see my mistakes better and correct them."* This indicates the ***progression*** element and is further emphasised by Participant 4, "*…It motivates me to like, learn more so I can get better".* Progression allows students to locate themselves in an environment and provides them with an extrinsic sense of their own progress (Toda, Oliveira, Klock et al., 2019).

Students can use the average of each question of the activity as a means of motivating themselves to perform better in specific areas. The average provides an indication of how well a student is performing in each area. Setting goals and striving to improve will enable the student to monitor their progress and see how their performance is improving. Student motivation can be greatly enhanced by this approach.

According to the performance dimension, extrinsic motivation was an integral component as it pertains to the environmental response, which provides feedback to the learner by way of assessment (Toda, Oliveira, Klock et al., 2019). Extrinsic motivation is a type of motivation that results from external rewards and punishments (Cherry, 2022). It has been observed that this type of motivation has been used in the classroom, as students have been rewarded for their accomplishments with points as well as other forms of recognition. It is evident that participants felt motivated by receiving rewards, which in turn, stimulated their extrinsic motivation.

This study demonstrates an example of how gamified systems can be analysed and evaluated by users, using an existing taxonomy. In this paper, the findings have been described based on the elements participants used in the Book Widget application and analysed according to the five dimensions of the gamification taxonomy framework. In each of these dimensions, elements were designed to stimulate either intrinsic or extrinsic motivation in students. Ecological elements, for instance, enhance the interaction between students and the environment. In the social dimension, the focus is on the interactions between students. In terms of the personal dimension, the student is placed within the context of the environment. In the fictional dimension, the focus is on the experiences that create a sense of imagination or fiction. The performance dimension relates to the environmental response, which provides students with feedback regarding their progress and level of achievement. Based on the findings, gamified learning environments require both intrinsic and extrinsic motivation to be successful. An individual's intrinsic motivation is influenced by their interest in the activity, while an individual's extrinsic motivation is determined by rewards or punishments. For gamified learning environments to be successful, both kinds of motivation are needed to engage the student and increase their motivation to participate. Furthermore, the study demonstrates that careful consideration of the different elements can enhance student engagement and motivation. To conclude, the researchers intend to explore teachers' perceptions of the elements in the Book Widget application and evaluate them based on this taxonomy to identify the best practices for how to use the elements effectively. By pursuing this future exploration, we hope to be able to provide teachers, instructors, and developers with concrete guidelines for gamifying educational environments.

5. CONCLUSION

In summary, students confirmed that the five dimensions mentioned in the gamification taxonomy of Toda, Klock et al. (2019) are evident in the Book Widget app and contributed to both their intrinsic and extrinsic motivation. Students experienced the application positively as it contributed to increased motivation and engagement. Students enjoyed completing the activities and felt a sense of encouragement to learn. Often, the gaming elements within Book Widgets work together to contribute to student experience. Book Widgets, as a gamified learning environment, does, however, present some shortcomings. It is recommended that further evaluation of the application be performed to explore other identifiable elements. Alternatively, a review of the application can be conducted to improve the gamification to include elements that are not yet included. It is further recommended that more studies be conducted, looking at how the gamification elements contribute to the learning of different subjects.

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A GAME DESIGN MATRIX FOR EVALUATING THE MOBILE READINESS, EASE OF USE AND EDUCATIONAL CAPABILITIES OF INTERACTIVE WEB-BASED ACTIVITIES

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ABSTRACT
Having an insight into gamification and game design is essential in shaping a contemplative understanding of the capabilities of mobile technologies, as well as capitalising upon their advantages for learning and learner engagement. Therefore, it is important for teachers to acquire digital content design skills, develop computer-mediated communication competencies, and learn how to utilise available tools for designing mobile, game-based learning activities that fit their students' needs and the learning outcomes, alike. This paper proposes a Game Design Matrix which serves as an evaluation instrument to assist teachers in exploring the appropriateness of various web-based, interactive activities along 5 dimensions: ease of use and accessibility; compatibility with mobile devices; gamification parameters (game mechanics and game dynamics); type of assessment; and learning objectives they serve utilising Bloom's taxonomy. Several H5P templates are analysed and evaluated based on the proposed Matrix as demonstration of its analytic function.

Keywords: mobile learning; mobile devices; ease of use; accessibility; Bloom's taxonomy; gamification; interactive activities

1. INTRODUCTION

The uptake of mobile devices and mobile learning has been accelerated in recent years (Karakaya and Bozkurt, 2022), with specific interventions in a multitude of domains, such as science education (Zhai

& Jackson, 2021) and language learning (Poláková, 2022), in need of establishing a bridge between teachers and students, and among peers, during a period of drastic social changes and technological disruptions (Piki, 2020). However, the transition to remote education and the adoption of mobile and blended learning practices was far from smooth. The readiness for mobile learning remains open for analysis, both from the student (Yalcinkaya and Yucel, 2023) and teacher perspectives (Lu and Xiong, 2023; Chen and Tsai, 2021). Research has highlighted both the opportunity brought by mobile technologies (Fang et al., 2023), as well as the complexity of factors influencing mobile learning, and significant barriers (Chen and Tsai, 2021), especially in the context of accommodating the needs of disabled learners, regardless of their age (Klimova, 2023; Lendzhova et al., 2023). Moreover, along with the social uncertainty and the difficulties caused by the pandemic, the need to attend to students' wellbeing and satisfaction (Jeno et al., 2022), and other prevalent educational challenges, such as (re)engaging students, nurturing their interest, and igniting their curiosity (Stefan et al., 2022), teachers have been facing several practical challenges. Firstly, while many teachers invest a lot of effort into creating a positive learning atmosphere (Liu and Lai, 2023), they are still unfamiliar with online, mobile, gamified, and blended approaches to learning. This often resulted in improvisations and adoption of ad hoc solutions, especially during emergency remote teaching (ERT), which many students found confusing (Piki, 2020). Secondly, despite the inherent capabilities of mobile technologies to engage learners with diverse abilities and preferences, the lack of digital skills in effectively using the available tools and technologies fragmented the established connections between students, teachers, activities, and learning outcomes (Piki, 2022) while the educational needs of disadvantaged learners and learners with disabilities were often neglected (Stefan et al., 2022).Thirdly, traditional instructional materials are often rigid and do not allow for personalisation or customisation to meet diverse needs. The lack of inclusive, accessible, readily available, and easily customisable digital resources, that match the learners (dis)abilities, level of education, subject, or language of instruction, resulted in significant overheads in preparing instructional materials. Teachers had to invest additional time and effort in redesigning learning activities from scratch or creating alternative learning materials, to replace those prepared for classroom-based instruction with fully digital activities (Piki et al, 2022a). The possibility to collect and understand feedback from learners for mobile experiences is of equal importance (Wei, 2023) and remains also problematic. Even if game-based learning has flourished in the last decade and gamifying mobile experiences to support assessment of students' learning outcomes provides a useful uptake (Kao et al., 2023), the design of such gamified activities requires specific competencies that teachers must develop.

In this paper we propose a Game Design Matrix which can serve as an evaluation instrument to assist teachers in exploring the appropriateness of various web-based, interactive activities or develop new ones. The Game Design Matrix considers 5 dimensions: ease of use and accessibility; compatibility with mobile devices; gamification parameters (game mechanics and game dynamics); type of assessment; and learning objectives they serve utilising Bloom's taxonomy. We provide an analysis of various interactive activities designed for desktop environments with the aim of gaining a deeper understanding of their compatibility with and readiness for mobile use. This approach eases the burden teachers may face when transiting such interactive activities to mobile environments, and provides guidance for the creation of digital resources that can be successfully used in mobile learning settings. The interactive activities analysed herein were created utilising H5P templates available on Moodle Learning Management System (LMS). The proposed Game Design Matrix has been utilised to analyse the activities and provide guidance on mobile-compatible H5P templates.

2. BACKGROUND

The Need for Digital Skills Development in the Post-Pandemic Era

Several initiatives have been proposed in recent years towards addressing digital skills gaps, including the ‘Path to the Digital Decade’ policy programme, investing on professional education and upskilling (European Commission, 2021). Such initiatives involve upskilling and reskilling to make the best use of new digital technologies (Digital Skills & Jobs Platform, 2021). In the latest ‘Future of Jobs Report’ (World Economic Forum, 2023), technological literacy is listed as one of the top seven skills for 2023-2027, while the European Commission has proposed 2023 as the ‘European year of skills’, in an effort to give a fresh impetus to lifelong learning by promoting increased, and more effective and inclusive investment in training, reskilling and upskilling. The aim in highlighting these needs is to harness the full potential of every individual, ensure that skills developed are relevant to contemporary and future needs, and that the digital skills gap is tackled (European Commission, 2022). Furthermore, as outlined in the Digital Decade strategy, “digital skills, basic and advanced, will be essential to reinforce our collective resilience as a society” (Digital Skills & Jobs Platform, 2021). This applies in every workplace including education. Teachers in all levels of education need to constantly adapt to changes and embrace the available tools and technologies. To do so effectively they need to acquire digital content design skills, learn how to design materials suited for mobile devices, apply gamification techniques to learning activities, select appropriate game mechanics according to their students’ talents and needs, and familiarise with available tools and resources which can be synthesised for designing efficient and engaging mobile learning activities. With an increasing focus on equality, diversity, and inclusion, it is also essential to learn and understand how design decisions affect diverse learners. We argue that ‘designing learning activities for learners with disabilities includes all learners’.

Game-Based Learning (GBL): pedagogical benefits and challenges

Game-based learning (GBL) is commonly associated with numerous benefits: it triggers creativity and creative thinking, active exploration, imagination, and happiness (Ferguson et al., 2019); it activates motivation, engagement, and social interactions (Zainuddin et al., 2020); it helps learners to reflect on their experiences, become self-aware and self-directed, construct meaning in authentic contexts (Ray, 2020; Rigby, 2014) and achieve greater goal orientation (Ding, 2019); it promotes constructive, competitive and collaborative learning (Ding, 2019); it encourages tinkering and eliminates the need for memorisation and performance achievement (Ferguson et al., 2019) through trial-and-error and through learning from ‘positive or productive failure’ (Ferguson et al., 2019). These qualities can collectively increase learner engagement and motivation and, in turn, enhance the learning outcomes (Zainuddin et al., 2020).

Nevertheless, attaining the aforementioned benefits is not straightforward for teachers, especially when it comes to mobile game-based learning (mGBL) (Piki et al., 2020; Zainuddin et al., 2020). Despite the increasing availability of ready-made games and the widespread use of mobile devices, creating personalised mGBL activities remains a multifaceted challenge. Firstly, it is not always possible to find games in the required language, level of education, or quality. Secondly, customisation of available games is rarely possible. Thirdly, even if such customisation options are available, most teachers do not have the necessary digital skills to shape the games to fit their students' levels, talents, and disabilities. Fourthly, assessment resurfaces as a tenacious challenge in mGBL since it is hard to assess the learning outcomes, and most games do not incorporate monitoring and assessment features. Another important element is the need to ensure that learning remains flexible yet scaffolded, and that learners are supported at the required level which is adjusted according to their needs and (dis)abilities (Stefan et al., 2022). The latter is an important consideration which requires taking into account individual characteristics, needs, and preferences (Böckle et al., 2017; Raleiras et al., 2020; Hallifax, et al., 2019), diverse learning styles, approaches to studying, and engagement profiles (Piki, 2017; Piki et al., 2020). Yet, the time and effort teachers need to invest in personalising content, feedback, and assessment is often unrealistic and impractical.

In light of both the benefits and the challenges associated with GBL, there is a need to explore the available tools and platforms that enable educators to easily create content such as interactive videos, quizzes, and presentations. One such platform is H5P (h5p.org) which is discussed next.

Mobile friendly content and interactive learning activities with H5P

H5P – an abbreviation for HTML5 Package – is a free, open-source framework whose aim is to make it easy and straightforward for everyone to create richer interactive web-based, mobile friendly content; to reuse and modify content directly on a browser; and to share content seamlessly across any H5P compatible site (h5p.org). H5P makes it easy to create interactive content by providing a range of content types for various needs, and this content can be integrated on VLEs and LMSs. Interactive videos enriched with user interactions, branching scenarios introducing dilemmas and self-paced learning, Augmented Reality (AR) scavenger fun activities, drag and drop tasks with images, image hotspots and interactive images, QR codes, memory games, interactive 360o virtual tours, and quizzes are only a few of the available templates (h5p.org). Given the wide array of available templates, a tool which can assist in evaluating their appropriateness and readiness to be used for mobile learning was deemed necessary. Therefore, we propose a model that can be employed in this endeavour as discussed next.

3. GAME DESIGN MATRIX

A Game Design Matrix (GDM) has been created to support the analysis and evaluation of interactive activities along five key areas: (1) Ease of use and accessibility (a rating is applied on a scale of 5 stars). The GDM includes information on the combability with mobile environments (a 3-tired mobile support, where level 1 represents full compatibility for use on mobile devices, and 3 is a low mobile compatibility); (2) Compatibility with mobile environments (mobile support); (3) Gamification features (game mechanics and game dynamics); (4) Type of Assessment; (5) Learning objectives based on Bloom's taxonomy. Under Gamification features the following parameters were analysed:

- *Dynamics* (narration, levels, challenges, tips/clues, time pressure):

- Narration was selected to evaluate what templates can support the designing of context-based approaches, meant to primarily create engaging interactions between theoretical information and real-life cases.
- Levels was selected to evaluate the capacity of a template to support the creation of a reward system to encourage students to continue an activity, obtain feedback and discover more information.
- Challenges was selected to evaluate what templates can support the acquisition of problem-solving skills, while creating interesting and enjoyable learning experiences.
- Tips/clues was selected to evaluate which templates can offer further support for students during the learning and assessment processes by providing additional information, as well as motivational triggers for students to explore and discover what is hidden in the activity.
- Time pressure was selected to evaluate the templates that supports the designing of activities that allows teachers to evaluate the competence and performance of the students, as well as to analyse how the student's behaviour changes regarding exploration and decision making in the given period of time.

- *Mechanics* (exploration, self-learning, matching, competition, problem solving:

- Exploration was selected to evaluate the templates that enable the designing on new areas within the activity, where students can discover information, secrets that may be hidden away from plain view. This mechanic allows students to experience different environments, extend the narratives and even solve puzzles and quizzes.
- Self-learning was selected to evaluate the templates that support self-reflection and self-evaluation of the students learning goals, without the assistance of another person, only based on the information provided in the activity.
- Matching was used to evaluate the templates that allows the creation of activities which evaluate the comprehension and understanding of different subjects starting from an image or a graphical element, with a focus on deep-learning.
- Competition was selected to evaluate the templates that allows the creation of activities where students are motivated to achieve their goals and to encourage them to work harder. It was also used to identify the templates that support the creation of game-like activities.
- Problem-solving was used to evaluate the templates that support the design of problem-centred stories, where students are encouraged to use logic and creativity.

The proposed GDM draws on the Bloom's Taxonomy (Persaud, 2021) which is reinforced in learning contexts towards meeting educational objectives (Adesoji, 2018; Sudirtha et al., 2022) and instilling 21st century skills (Peña-Ayala, 2021), technology enhanced learning (Al Maani, D., & Shanti, 2023), scientific literacy and creative thinking (Pujawan et al., 2022). The following six categories are utilised during evaluation: remember, understand, apply, analyse, evaluate, and create. Several H5P templates have been analysed to evaluate their combability for mobile use. The analysis concerned the template structure, and it was carried out in connection with an interactive activity developed with that template. In the following paragraphs we provide a brief description of the particular template, an overview of its design, the features of the interactive activity, the learning objectives and assessment types it serves, the main educational objectives and applicability of the particular template, and ultimately its usability and accessibility when used with mobile devices.

Table 1. Synthesis of analysis for interactive activities.

Templates	Mobile support	Difficulty (1 to 5 stars)	Dynamics					Mechanics					Bloom's Taxonomy					
			Narration	Levels	Challenges	Tips/Clues	Time pressure	Exploration	Self-learning	Matching	Competition	Problem solving	Remember	Understand	Apply	Analyse	Evaluate	Create
Quiz (question set)	Level 1	*		■	■	■			■	■			■	■	■	■		
Drag and drop	Level 2	**				■			■	■			■	■		■		
Course presentation	Level 2	***	■						■	■		■	■	■	■	■		
Interactive video	Level 3	****	■	■	■			■	■			■	■	■	■	■	■	
Virtual tours	Level 2	*****	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

The Virtual tours template can be used to create a more interactive and meaningful experience as it enables teachers to create both in classroom/outside of the classroom activities. The activities can give students the opportunity to stop, explore and guide learning at their own pace or as a challenge. While they are exploring, they can get up close to nature or surroundings that might not otherwise be easily accessible. Although the template allows the creation of more interactive activities in which the students' motivation can be greater, from the point of view of the time allocated to the creation, the template is more difficult than the others because it depends a lot on the applied context, on the information that must be covered and especially on the graphic side which is not always available to teachers, they have to use other tools to generate panoramic images or have photography skills.

Interactive video activities can offer a highly interactive and meaningful experience only on classroom/home locations. The template has a level 4 of development difficulty (depending on existing videos to be used or videos created from scratch). In the context of videos created from scratch the difficulty is increased as the teachers must use external tools to create the videos. Beside the skills needed to use such tools, the teacher must have on hand the content that can match with the graphics used.

Quiz, Drag and drop and Course presentation are easier to deploy but they do not provide a high interactivity as interactive video or virtual tours, and student motivation depends very much on the applied context and especially on the way in which the information is presented.

Regarding the usability on mobile devices from all the templates analysed only the template Quiz (Question set) offers a proper user experience on mobile, and is classified on level 1 on mobile usability. The content in this template is displayed on the entire screen and navigation is the activity is easy. The templates Drag and drop, Course presentation and Virtual tours, are classified as level 2 because there are some aspects related to the display of the content, in all 3 cases the content is not displayed on the entire screen and no full screen options are offered. Also, the way in which the activities are loaded and opened depends a lot on the size of the images, graphic elements and multimedia elements used. The template interactive video is classified as level 3 regarding mobile usability, because the template does not offer a full screen option and because the content is not displayed on the entire screen, the interaction is hard to follow both in portrait mode and landscape mode. There is also the problem with the stop, play and click on interaction buttons because in portrait mode is hard to access and in landscape mode it requires a scroll in the page. Because is a video-based activity, the loading is much slower than in the case of the other templates.

4. DISCUSSION AND CONCLUSIONS

Several good practices were defined to inform teachers on how they can better the employment of the H5P templates and create activities that can be used on mobile:

1.Setting up de goals and learning objectives. Starting from the mechanics and dynamics that can be applied in each template, the learning goals must be designed considering the following characteristics:

- Behaviour and results: the learning objectives should describe what students will know or will be able to do as a result of what they're learning, not what it is taught.
- Observation: It should describe the behaviour of the students derived from the dynamics of the template.
- Specificity: It should describe activities or knowledge that students can gain from the activity (or other instructional unit) and not be overly broad or narrow in scope.

2. Preparing narratives or text-based content for mobile contexts. A prior analysis of the template should be carried out prior to the design process to decide how to divide the narratives or the text-based content, considering both the restriction that apply to the template, but also the fact that the text will be displayed on mobile devices. Best practices that apply:

- Prioritize content and focus on what is most important.
- Break down narratives/content into meaningful pieces and keep them short.
- Define narratives or text-based content which support the learning objective.

3.Preparing images or graphics and resize them to be displayed properly on mobile devices. Choosing images or any graphic elements for the activities should not be an after-thought. A relevant image is considered as a powerful instructional method that drives students' engagement and motivation, reduces the cognitive load of the students, and helps to more efficiently fulfil of the learning objectives. Best practices that apply:

- Evaluate the image or the graphic element by its relevance with the narratives/text, and by its complexity. It is important to decide if the activity should be designed starting from an image and develop the content according to it or otherwise. It is important to establish that the image clarifies the content and match with the learning objective. When designing narrative based activities, look for images with people in them and use them to tell the narratives.
- When choosing the images or graphic elements pair them with key words. This is an important aspect as the images defined in the template should always be accompanied by alternative text.
- Use emotional colour palettes, but consider the accessibility of them in case that the activity is designed for disabled learners.
- Images and graphics of any kind, should be sized for mobile devices usage, as small as possible to balance quality against download speed on mobile networks and file size against mobile data.
- Activate the option in the template which allow the resize of the images (zoom in/zoom out).

4. Recording videos (for interactive video, course presentation or virtual tours). Students engagement is a key priority in both teaching and learning, but understanding how to engage the students and what methods can be used in the learning process can be difficult sometimes. An interactive training video allows students to click, drag, scroll, swipe, and hover over the content, revealing more details with each interaction and thus engaging students throughout the entire process and stimulating their creativity and curiosity

The use of interactive videos ensures full participation of students in the learning process, and which is a major source of learning. The fundamental difference between only text-based content and interactive videos is that students not only revise and reinforce their knowledge, but also build on it and complete it with new material. However, creating interactive content based on videos for teaching and learning can be challenging as it requires both time and technical skills. During the design, test and play sessions we identified the following best practices, regarding the design and deployment of the interactive video activities:

- Each interaction defined should be set to pause the video
- Begin each interaction with a heading 2
- Provide instruction at the beginning of the video or as external instruction in the course.
- Add alt-text descriptions up to 150 characters for meaningful images
- Use good colour contrast if text is applied on images
- Provide accurate captions that include all meaningful audio. The video analysed was developed in Microsoft PowerPoint which is a useful tool that can support both the caption definition but also the translation of the content.

As recommendation for playing on mobile devices it is best if the activity is played on portrait mode.

5. Copyrights and fair use. One of the unique things with H5P activities is that H5P tool allows interactive content to be editable and reusable for everyone. Taking into consideration this aspect, it is recommended to use images, graphic elements, videos for which you have copyright rights, the same applies to the text used.

6.Accessibility rules. The Content types recommendations maintained by H5P lists all the templates provided by the tool that appear to support WCAG 2.1 level A and AA accessibility standard. A key recommendation for all templates is to follow the WCAG 2.1 level A and AA accessibility standards regarding the usage of images (provide always alternative text) and ensure good colour contrast. Further recommendations identified for the templates that were analysed:

-For quizzes (question set): Each activity should include a heading 2 at the beginning.

-For drag and drop: Add instructions for questions on the frame of the activity.

-For course presentation: Slides have to be defined in the same order as they should be read; Slides should include a heading 2 at the beginning of each slide; It is recommended to not activate the auto-play of the slides; It is recommended to use the Active Surface Mode because students will be provided with instructions about navigating the activity with the keyboard or with screen reading software.

-For interactive video: Each interaction should include the option to pause the video; Each interaction should include a heading 2 at the beginning; Add instructions for questions on the assessment frames; Provide accurate closed captions

-For virtual tours: This activity can be difficult to play using a keyboard or for students that use screen reading software. The template does not provide an option to include longer alt-text descriptions for images more than 150 characters. As a recommendation, when adding images, teacher must include separate text immediately after the image.

This paper provides a practical approach that informs the design processes of interactive activities. The GDM and the recommendations empower teachers to adopt cost-efficient strategies and take informed decisions when creating dual content that can be used for desktop and mobile settings. Future work will focus on the extension of the matrix based on the analysis of other H5P templates that have the potential for mobile compatibility.

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CHALLENGES IN THE IMPLEMENTATION OF VIRTUAL REALITY IN CONSTRUCTION EDUCATION AT A SOUTH AFRICAN INSTITUTION

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ABSTRACT
Virtual reality (VR) based learning methods are steadily gaining popularity. VR can add a valuable virtual resource component in a learning environment, allowing students to gain practical experience to achieve a learning goal. Assisted by VR, students can actively learn and build their knowledge by exploring virtual environments they could not access. While numerous studies have highlighted the benefits of AR and VR technologies globally, most South African higher education institutions have not yet adopted these technologies' potential to assist experiential learning in the Built Environment. This study looks at the challenges surrounding the implementation of VR in construction education at the University of KwaZulu-Natal (UKZN) from the academic and student perspectives. This qualitative study consisted of a VR demonstration to academics and students, followed by semi-structured interviews with six academics and two focus group interviews with students in the construction and land surveying disciplines. The data was thematically analysed using the NVivo software. The identified challenges were infrastructure limitations, funding constraints, the skills gap, pedagogical adaption, and awareness and acceptance. The focus group interviews with the students also highlighted that students were not exposed to these technological advancements, such as VR, and are not fully aware of how these innovative technologies are used in the industry and the classroom.

Keywords: construction education; tertiary institutions; virtual reality

1. INTRODUCTION

Introducing brand-new learning techniques might be challenging for most individuals, both those learning and those teaching. New teaching and learning methods are required due to technological advancements to ensure that results are as efficient as possible. Over the years, educational institutions have looked for better ways of making the learning and teaching experience more effective and convenient for learners and teachers by introducing various learning methods, including e-learning, in higher education.

Virtual reality (VR) is an advanced digital project delivery technology currently used in the construction industry to enhance a construction project's precision, efficiency, and comprehensiveness. Students in the built environment need to understand the construction processes through visualisation (Jaruhar, Messner & Nikolic, 2011). Students do not have the experience or expertise to make informed decisions and judgments about construction activities. Therefore, envisioning the theory being taught to them would play a key role in enriching their comprehensibility and help students draw a defined link between the theory being taught, actual construction processes, and finally, its end products (Jaruhar, et al., 2011).

While numerous studies have highlighted the benefits of VR technologies globally, most South African higher education institutions have not yet adopted these technologies' potential to assist experiential learning in the built environment. Currently, the University of KwaZulu-Natal (UKZN) does not have any VR equipment for construction and land surveying students, nor have these students been exposed to VR on campus. Therefore, this study was undertaken to understand the challenges surrounding the implementation of VR in construction education at UKZN from the perspective of academics and students. Further studies will examine the student's experience using the VR equipment and the associated challenges.

2. LITERATURE REVIEW

2.1 Virtual reality as a tool for education

Technology has become an integral part of our existence in the modern world (Jantjies et al., 2018). It is frequently used in educational institutions to improve the teaching and learning process (Jantjies, Moodley & Maart, 2018). Due to its capacity to fill in gaps and provide a more practical approach to learning, VR technology has garnered popularity in the educational sector (Jantjies, et al., 2018).

VR is described as a believable and interactive 3D computer-created (virtual) environment that a user may be immersed in, with the environment being experienced and interacted with through visual, tactical, auditory, and sensory stimuli (Lackey & Shumaker, 2015). A completely new environment is created so that participants can get a sense of being part of it, interact with it, and even change it as they see fit without being interrupted by the real world. This technology works in such a way that the simulation engages the human body's five senses in a way the user begins to believe that they are present in the real-life environment (Nguyen, 2014). The users of VR systems can physically walk around computer-generated objects and perceive them as if they were real.

Including virtual and real-world experiences enhances student-centered activities (Dunleavy, Dede, & Mitchell, 2009). Assisted by VR, students may be able to actively learn and build their knowledge by exploring a virtual environment they would not be able to access (Dunleavy, Dede, & Mitchell, 2009), and the lecturer facilitates learning rather than merely transmitting information (O'Neill & McMahon, 2005). Students in the architectural, engineering, and construction (AEC) disciplines are taught to examine and interpret buildings and structures by appraising 2D drawings and designs (Whisker, Yerrapathruni, Messner & Baratta, 2003). Although strategies such as CAD are used to demonstrate designs in a 3D presentation, a few advanced visualisation tools are used in tertiary education (Henriques, Martins & Sampaio, 2010).

VR allows students to immerse themselves in tangible experiences that allow them to change their perspectives and approaches to learning (Jantjies et al., 2018). Virtual field trips, laboratory experiments, and projected videos give students advantageous educational experiences. Horne & Thompson (2008) believed that seeing the 3-dimensionality of objects and surrounding environments from its initial stage to the final operation of the product allows one to comprehend and fully appreciate the built environment. VR has made it possible to assist all engineering, construction, and land surveying students in visualising the stages and procedures occurring on construction sites using VR equipment (Hamza & Horne, 2006).

2.2 Benefits of using virtual reality in education

One notable benefit of VR is that it provides a practical means of enhancing and acquiring new cognitive abilities. While there are various ways to accomplish this, Maheshwari & Maheshwari (2020) claim that VR does so more effectively and to a greater extent. Martín-Gutiérrez et al. (2016) have drawn a definitive link between virtual technologies and improvements in a student's educational performance, motivation, and concentration. The challenge of participating, constructing, and influencing objects in a virtual environment excites students and holds their attention. Virtual technologies can potentially enhance a student's interpretive and problem-solving skills and facilitate permanent learning (Yilmaz, 2018). VR can also aid in learning complex topics, allowing students to experience and visualise them in a virtual setting (Boyles, 2017). Another advantage of VR is the ability to personalise instruction. With self-directed learning, students can choose classes that best suit their learning preferences, and VR also creates a focused setting that reduces outside distractions (Maheshwari & Maheshwari, 2020).

Virtual reality allows students to experience, virtually see, touch, and hear the content being imparted to them (Rawal, 2018) rather than imagine circumstances and situations. The virtual world provides a more controlled environment than the actual world. Therefore, lecturers can manipulate what is presented to students to transfer the optimum amount of information (Christou, 2010). The immersive quality of virtual reality can also help students block out outside distractions to concentrate on the learning objectives (Boyles, 2017). VR can be used when teaching via the actual environment; for example, a construction site is dangerous, impossible, inconvenient, cost-inefficient, or too time-consuming (Horne & Thompson, 2008). Furthermore, a student is given a chance to encounter subject matter that would otherwise be challenging to convey using conventional methods, thereby proving to be a valuable support mechanism to conventional learning paradigms (Bilyk, 2018). Through VR, features and components commonly called "hidden details" in traditional tools can be discovered and inspected more closely, producing transformations that would be impossible in actual reality (Antonietti, et. al., 2000).

An area of concern of the modern education structure is its inadequate capacity to define and exemplify complex concepts and clarify them more practically. The current way of explaining ideas is frequently a 'hit and miss affair' in which some students understand the concept while some of their colleagues cannot (Bilyk, 2018). While this does not pose a significant challenge in humanitarian sciences, it becomes critical in biology, physics, chemistry, and construction education. Using VR educational apps, including interactive audio-visual aspects, makes explaining complicated concepts less challenging.

2.3 Challenges experienced in the implementation of VR in *education*.

While VR offers impressive opportunities for students in construction education, there are still several conflicts and obstacles that may be faced in employing the use of these versatile technologies. How virtual technologies can be smoothly blended into the educational process is still being studied (Martín-Gutiérrez et al., 2016). There are frequent restrictions on the different resources available in any educational setting. This is most frequently observed in the conventional classroom (Serio et al., 2013). The ability to teach students in situations that enable them to learn by doing can be difficult due to budget and time restrictions (Serio, et al., 2013). Extra time is needed for teachers and pupils to learn how to use their virtual reality equipment (Boyles, 2017), and funds are needed for the acquisition of VR equipment, which is challenging, especially for organisations with limited budgets (Maheshwari & Maheshwari, 2020).

There are additional expenses, such as paying for teachers to receive training to use this technology, for maintenance, and for purchasing VR learning resources (Maheshwari & Maheshwari, 2020). Since most teachers do not have the time or the necessary technical skills to develop their own virtual reality apps, third parties will likely be required to develop and maintain these programs and the content that goes with them (Boyles, 2017). Another disadvantage is the lack of a genuine, totally immersive experience because modern technology makes it simple for consumers to tell the difference between the real world and a virtual one (Maheshwari & Maheshwari, 2020). There is also the issue of safety and health problems brought on by immersive experiences (Serio, et al., 2013). There were numerous instances of cybersickness, when users experienced physical discomfort and nausea after using immersive VR technologies (Maheshwari & Maheshwari, 2020).

3. METHODOLOGY

The research was conducted in two phases. Phase one involved the demonstration of VR to final-year students and academic staff who were purposively sampled in the Land Surveying Discipline. A local architectural firm was approached and consented to conduct a live VR demonstration on campus for staff and students. After the architects set up the equipment, they provided a brief presentation on what VR is and how they use it in the industry. The students were then able to use the VR equipment. The second phase involved the purposive sampling of academics and students in the construction and land surveying disciplines at UKZN. The primary goal of qualitative research is to study, uncover, and understand a group of people's thoughts, feelings, and perceptions (Saunders, 2012); therefore, the qualitative approach was deemed appropriate.

Semi-structured interviews were conducted with six academics to acquire in-depth information about the subject being studied. The researcher employed a funnelling strategy, starting the interview with simpler questions to relax the respondents before moving on to more detailed questions. Two focus group interviews (Flick, 2017) were also conducted with final-year students. Each group consisted of seven students to obtain the student's opinions on the topic. Focus groups are characteristically made up of six to ten participants. However, the group size can vary from a minimum number of participants of four to as many as twelve, depending on the research type (Flick, 2017); therefore, the sample size of seven was considered adequate. The focus group lasted 75 minutes, in which students were asked a set of questions, and opinions were provided to the researcher. The data was captured on NVivo to assist with analysis and interpretation. The data was organised, categorised, and coded to identify and establish relevant themes.

4. RESULTS AND DISCUSSION

The six academics had an average of 15 years of academic experience. None of them had used VR in any of the modules they were teaching, but they felt they could provide some valuable insight into the possible challenges to VR implementation at UKZN. The academics unanimously felt that VR technology should be introduced at UKZN in the built environment disciplines for two main reasons. Firstly, to help students visualise the theory taught to them, allowing them to encounter realistic, construction-related scenarios in a controlled environment. Secondly, so that students can familiarise themselves with these technologies before they go into industry.

Two focus group interviews were conducted with 14 students in their final year of study. The focus group interviews highlighted a critical finding: the students were not exposed to technological advancements in industry or the classroom because most students did not know what VR was and its potential application in education. After using the VR equipment, the results showed that students are eager to have VR implemented into their learning methods. Although students have not used VR in a lecture room before, they did see some of the benefits of using technological tools versus conventional learning because they felt that VR would help prepare them for the industry as they could better visualise the content taught to them. According to the academics and students in the construction studies and land surveying disciplines, UKZN faces certain challenges when adopting VR technologies in the classroom. Figure 1 shows the main themes that emerged from the data analysis, namely, infrastructure limitations, funding constraints, skills gap, pedagogical adaptation, and awareness and acceptance.

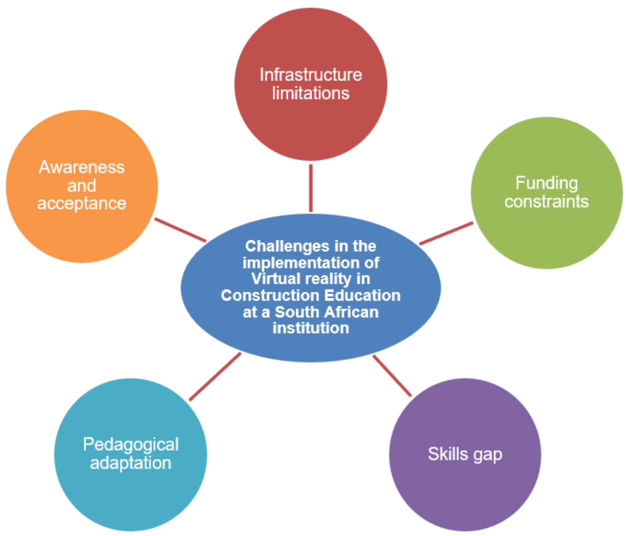

Figure 1. Mind map of themes.

4.1 Infrastructure limitations

One critical challenge stated by academics and students is the lack of adequate infrastructure required to support VR technologies. "*Access to high-speed internet connections and the necessary hardware for the big classes we have is going to be a major challenge,*" stated Academic 3. A reliable power supply is also a limitation, as noted by Academic 2, who stated that "*the extended load shedding we are experiencing will force us to cancel lectures and revert to the traditional methods of teaching*." The lack of a reliable, sustainable electricity supply will undoubtedly hamper the widespread implementation of VR technology.

The students believed the technological tools were unreliable in lecture rooms, agreeing that if the VR equipment malfunctions, it could hinder the lectures being taught, waste valuable time, and create a distracting learning environment.

4.2 Funding constraints

South African universities often struggle with financial constraints, and implementing VR technology can be costly. Limited funding makes investing in the necessary equipment, software licenses, and training for educators challenging.

The academics felt that cost and accessibility would be a difficult challenge to overcome because "*a significant financial investment, including the purchase of hardware, software, and maintenance costs, is required for the implementation of VR technology*" (Academic 1). This can limit access and availability, particularly at UKZN, with limited resources.

While the students agreed that an immersive experience could be better than a theoretical lesson, they felt it would be too expensive to implement in educational facilities. VR experiences rely on specialised equipment like headsets, which can be costly for individual students. Most students cannot afford this; Student 10 stated, *"I have a study loan, and purchasing additional VR equipment is not something I can afford*." Student 6 stated that "*there could be additional costs in terms of maintenance if the disciplines bought the headsets and lent them to students, as the students could damage them*."

4.3 Skills gap

Lockwood (2004) emphasized that to fully exploit virtual technologies' potential, work-related content must be locally produced to account for the diverse languages spoken and understood in South Africa.

However, the lack of skilled professionals who can develop and integrate VR technology into the curriculum poses a challenge to its implementation. UKZN could struggle to reallocate funds to invest in specialised VR training programmes. Training educators to effectively use and incorporate these tools into the existing pedagogical practices requires time, resources, and expertise because none of the six academics interviewed knew how to do this. Academic four stated, "*I am three years away from retirement; I will leave all this to the younger academics to learn*."

There also seemed to be some resistance from students in learning how to use VR technology, with Student 3 stating, "*I do not like using technological devices to prepare and learn…*" The lack of proper understanding of how VR was used resulted in the student's lacking confidence in using this technology.

While the newer generation of students possesses competent technological skills and is more exposed to new technology, it cannot be concluded that all students are automatically capable of using these advanced technologies in an educational environment (Martin-Gutierrez et al., 2016). The academics and students felt that constant VR training is needed before and after its implementation so that the technologies are easier to use and understand.

4.4 Pedagogical adaptation

Integrating VR technology into the classroom requires a shift in pedagogical approaches. Academics must update their teaching methods and develop new instructional materials to incorporate these technologies effectively. This transition can be time-consuming and challenging for educators. Academic Five reiterated this: "*Support and training would be needed to understand how to effectively incorporate these technologies into existing lesson plans and teaching strategies*." "*The integration of VR technology into the curriculum is not seamless. It will take time and effort*", stated Academic 2.

Integrating VR into the curriculum requires careful planning and alignment with learning outcomes. "*I foresee us facing many challenges in developing suitable instructional materials, adapting teaching methods, and integrating these technologies into the existing curricula*," stated Academic 1.

The helplessness of the academics could be felt when they made heartfelt comments such as that of Academic 4, who stated, "*I just don't have the expertise required to design meaningful learning experiences in VR environments, and I don't know how long it will take me to acquire this*." Insufficient expertise in these areas can hinder effective implementation.

Academic Three felt that "*VR environments can be a distraction that diverts students' attention away from the intended learning objectives*." It is crucial to carefully design and manage the VR experiences to minimise potential distractions, but "*I don't have the knowledge or expertise to do this*."

Different students have varying learning preferences and styles. While VR technology offers immersive and interactive experiences, they may not align with every student's preferred learning approach. Some students may prefer traditional instructional methods or find VR experiences less engaging or effective for their learning needs.

From the student's perspective, they felt that the isolated nature of VR experiences may limit social interaction and collaborative learning opportunities compared to traditional face-to-face classroom settings. "*I am used to working in groups, and my friends often explain concepts to me that I don't understand…*" (Student 13).

While VR could assist in teaching by providing interactive experiences with virtual objects and providing students with opportunities to investigate different scenarios, the students felt that the traditional methods were more important. Student 9 stated, "*Theory is important, and there should be a balance between immersive and theoretical aspects."*

While some students considered that virtual site visits would help them better understand construction activities and complete assignments and tests, most did not think so. Student 6 stated, "*I prefer to go to the site and see for myself what is happening to understand it better*."

Another concern that the students had was the belief that it would create too much of a game-like environment and defeat the purpose of a strict learning environment, with comments such as *"We will focus on the technology rather than what we need to learn...*" (Student 12) and "*we might forget that we are on campus and in a lecture…*" (Student 14). The students admitted that they find it difficult to adapt quickly to using technological tools and felt that they would be overwhelmed by it.

4.5 Awareness and Acceptance

The awareness and understanding of the potential benefits of VR technologies in education is still relatively low among stakeholders in higher education. Convincing academics and students about the value and impact of these technologies will take time, especially if they are unfamiliar or skeptical about their benefits.

All the academics admitted that they did not have direct exposure to these technologies during their education or professional development, leading to a lack of familiarity and confidence in incorporating them into teaching practices.

The students also did not have prior exposure or experience with VR technology, resulting in uncertainty about the educational benefits of VR and how to engage with it effectively. Student 1 rejected the implementation of VR, stating, "*I prefer the traditional method of reading and learning from textbooks, and we need to keep these methods."* Students 2 and 6 also felt that VR should not be implemented because "*students are reckless with university equipment and could damage it.*"

The students' lack of awareness and acceptance was evident with comments such as "*I would still refer to 2D drawings to calculate the dimensions to get accurate values"* (Student 7).

The students also felt that the experience of having your body in one place and your mind in another was confusing and overwhelming, and it would take some time to adjust to it. Thereby highlighting the fact that the immersive nature of VR experiences can sometimes overload students' cognitive capacity, making it challenging to process information effectively.

It was interesting to note that the students also noticed that the academics might not "*have access to VR models*" and that lecturers may lack "*sufficient knowledge or experience to guide students in using this tool correctly.*"

The students further believed that if one is not technologically inclined, VR could prove to be hard to use, and "*it will require training and teaching people how to use it effectively and efficiently.*"

VR technologies can have a learning curve associated with their usage. Both academics and students might need time and guidance to become proficient in operating and navigating these technologies effectively. Difficulties in understanding how to use the tools and incorporating them into their learning processes can deter their acceptance.

Although academics and students want to embrace technological methods, the study indicates that traditional learning methods are still favoured over technological learning methods because of these challenges.

4.6 Overcoming the *challenges*.

Overcoming the challenges of VR adoption in higher education requires a multifaceted approach involving various stakeholders. Several strategies can help address these challenges, as discussed below.

UKZN needs to allocate resources to procure and maintain VR hardware and software and create dedicated VR labs equipped with the necessary infrastructure.

Partnerships could be formed between the various disciplines, the university, the government, and private sponsors to support the implementation of VR initiatives through funding and grants. The university could collaborate with VR companies to acquire equipment and software licenses at reduced costs.

Training and support need to be provided to the academics to familiarise themselves with VR technologies. Workshops, seminars, or online courses can also be offered to enhance educators' pedagogical skills in integrating VR into their teaching practices. UKZN must encourage interdisciplinary collaborations among academics to identify suitable curriculum areas or subjects where VR can enhance student learning.

Student engagement and support are critical because students need to be involved in designing and developing VR experiences. Addressing students' concerns and promoting acceptance of VR technologies requires proactive measures. These can include providing comprehensive training and support, ensuring accessibility and affordability, showcasing educational advantages through pilot programs and research, and incorporating student feedback into designing and implementing VR experiences.

By implementing these strategies, UKZN can foster a supportive environment for VR adoption, enabling educators and students to embrace these technologies and maximise their potential for enhancing teaching and learning experiences.

5. CONCLUSION

Education has benefited significantly from the rapid advancement of technology in recent years, particularly in higher education in first-world countries. Although developing countries such as South Africa are gradually catching up, there is still potential to reach and positively transform the teaching and learning experience. VR has the potential to improve experiential learning by giving students practical experience. This kind of technological teaching and learning has not yet been used at UKZN, notably in the field of construction and land surveying.

This qualitative study looked at the challenges surrounding the implementation of VR in construction education at the University of KwaZulu-Natal (UKZN) from the academic and student perspectives.

The identified challenges were infrastructure limitations, funding constraints, skills gap, pedagogical adaptation, and VR technology awareness and acceptance. The academic interviews revealed the staff's apprehension about VR adoption given the infrastructural challenges, such as the lack of reliable power supply, the high costs of VR hardware and software, and the pedological changes that will be required. The focus group interviews revealed that students saw the potential of VR if implemented in construction education by providing the link for theoretical and practical application. However, the students were also apprehensive because they thought VR could detract from learning and create a game-like environment.

It's important to note that these challenges are not unique to South Africa and can be observed globally in many other educational systems. However, addressing these challenges, such as improving infrastructure, providing training programs for academics and students, and fostering collaborations between academia and industry, can help accelerate the adoption of VR technologies in South African higher education.

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