



**Proceedings of the 53rd Annual Conference of
the Southern African Computer Lecturers'
Association (SACLA 2024)**

***“Humanising and Innovative Teaching and
Learning”***

**17–19 July 2024, Gqeberha
Boardwalk Hotel South Africa**

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Preface

The 53rd Annual Conference of the Southern African Computer Lecturers' Association (SACLA) was held from the 17th to 19th July 2024, at the Boardwalk Conference Center, Gqeberha (Port Elizabeth), South Africa. The Nelson Mandela University in South Africa organised the SACLA 2024 conference. This in-person conference served as a distinguished platform for exchanging original research and practical experiences, fostering dialogue on the teaching and learning of Information Systems, Computer Science, Information Technology and related disciplines. The event was co-located with the annual meeting of the South African Institute for Computer Scientists and Information Technologists (SAICSIT) for the third year, allowing the delegates to attend both events as there is a considerable overlap in the communities.

The theme of SACLA 2024 was “Humanising and Innovative Teaching and Learning” of Computer Science (CS), Information Systems (IS) and Information Technology (IT) education. Fifty-three papers were submitted to the conference and 31 papers (57%) were finally accepted, including one Work-in-Progress paper. Eighty-six delegates attended the conference.

The international programme committee comprised 42 members. A rigorous double-blind peer review process was followed for all submissions. Each submission was reviewed by at least three members of the program committee. This volume presents the collection of the 20 accepted papers (38%) presented at the SACLA 2024 conference. The top ten submissions, based on reviewer ratings are included in the SACLA 2024 Springer journal publication. Reviewer feedback was provided to the authors and the authors were requested to submit a change log file and rebuttal to the program committee to indicate how the reviewers' comments were addressed.

Two best paper awards were presented this year, the first award was presented to Carolien van den Berg (UWC) and Belinda Verster (CPUT) for their paper entitled “Bridging Local Realities and Global Goals: Exploring Student-Led Sustainable-Smart Innovation Projects in a Marginalised Community”. The second to Mark Brand, Jean Greyling and André Calitz (NMU) for their paper entitled “Inquiry into the Paradox of an ICT Skills Gap”. The two best papers were identified based on similar ratings that the reviewers indicated on EasyChair and the recommendations of the National SACLA Management Committee.

The organising committee invited three sponsors to give keynote presentations: Mr Cinga Nyangintsimbi, Managing Director of BATSAMAYI, Mr Tony Parry, CEO of the Institute of IT Professionals of South Africa (IITPSA) and Mr Nico Claassen (COO) of WiRK/DSA.

In addition to the paper presentations, a Head of Department (HoD) Colloquium was held, attended by HODs from 16 departments at 8 universities in South Africa. The SACLA 2024 AGM was attended by 47 delegates and the 54th SACLA 2025 conference will be hosted by the University of the Free State, in Bloemfontein, from the 30th July to 1st August 2025.

The Programme Committee would like to thank all the participants, including speakers, delegates and reviewers for their contributions to a successful SACLA 2024 conference. Finally, we wish to acknowledge the EasyChair conference management system, which was used for managing the submissions and reviews of SACLA 2024 papers. As for the preparation of this volume, we sincerely thank the SACLA 2024 Organising Committee for their assistance.

November 2024

Tapiwa Gundu
Noluxolo Gcaza
André Calitz



SACLA

SOUTHERN AFRICAN^{II}
COMPUTER LECTURERS' ASSOCIATION

2024 Gqeberha, South Africa: The 53rd Annual Conference

Our Sponsors

We want to thank our generous sponsors (Wirk, DSA, Batsamayi, aws, VSC, avochoc, Mercedes Benz, Tangible Africa and IITPSA) for their contribution to SACLA 2024.



BATSAMAYI



Message from the Conference Chair

Thank you for participating in the 53rd Annual Conference of the South African Computer Lecturers' Association (SACLA 2024). It was both a privilege and an honour to host all conference delegates at our beautiful Boardwalk Hotel in Gqeberha (formerly Port Elizabeth) during the week of Madiba celebrations. In celebration of Mandela Day, many conference delegates contributed a "Jar of Hope" for those less fortunate. These were very much appreciated!

The theme of SACLA 2024 was "Humanising and Innovative Teaching and Learning". The accepted papers that were presented aligned with this theme by reflecting on current and future trends in teaching and learning in Computer Science, Information Systems and Information Technology. We were impressed with the high academic research standard in the papers accepted for publication.

One of the goals of SACLA conferences is to allow delegates to network, share ideas, and learn from each other. Observing so many stimulating conversations between academics representing 11 universities across South Africa, including one from the University of Botswana was encouraging.

A further extension to the SACLA conference is the HOD meeting where HODs engaged on current challenges, insights and perspectives within various departments across the universities represented. This was well attended and ably chaired by Dr Sue Petratos.

On behalf of the SACLA community, I express our deepest appreciation to our valued sponsors, including WiRK, DSA, Batsamayi, AWS, VSC, AvoChoc, Mercedes Benz SA, Tangible Africa and the IITPSA. We were fortunate to have three guest speakers representing some of these sponsors, including Mr Cinga Nyangintsimbi (MD Batsamayi), Mr Nico Claasen (COO of Wirk/DSA) and Mr Tony Parry (CEO of the IITPSA).

The success of SACLA 2024 was due to the efforts of many individuals. We are grateful to the authors who presented their papers at this conference and the many reviewers who willingly gave up their time to provide valuable feedback to authors, ensuring a high standard of academic research. Well done to all programme committee members for bringing it all together!

I also extend my sincere thanks to all members of the organising committee and congratulate them on a job well done. A special mention of Michelle Brown, for her meticulous planning and organising of the logistics relating to the event.

We trust that all conference delegates left feeling inspired and re-energised from the paper presentations, fruitful conversations and valuable connections made during the conference.

We look forward to staying connected and wish the SACLA 2025 organising committee well at next year's conference.

Prof Lynn Fitcher
SACLA 2024 Conference Chair
School of Information Technology, Nelson Mandela University

Message from the Program Committee Chair

It is with great pleasure that I present the culmination of our collective efforts in shaping the program for the SACLA 2024 conference. This journey has been intense and rewarding, marked by insightful reviews and collaboration. I want to extend my heartfelt gratitude to our dedicated reviewers, whose expertise has been instrumental to the success of SACLA 2024.

I commend our authors for their timely submissions and adherence to critical deadlines, ensuring a smooth and efficient review process. Your willingness to share your research and contribute to the academic dialogue in this forum is truly admirable.

This year, we received 53 papers for review, a testament to the vibrant academic community engaged in Computer Science and Information Systems. Our program committee, consisting of local and international experts, comprised 42 dedicated members, with 17 contributing from the international arena. The rigorous double-blind peer review process involved three reviewers for each paper, with additional expert opinions sought whenever needed.

I am excited to announce that 30 high-quality papers have been accepted for presentation at SACLA 2024. Authors diligently addressed reviewer feedback after the peer review to further refine their work. Of these, 10 outstanding papers will be featured in the prestigious Springer publication, *Communications in Computer and Information Science*. As a result, only the titles and brief abstracts of these papers are included in this conference's proceedings.

Once again, my deepest thanks to our reviewers and authors for their invaluable contributions to SACLA 2024. Your efforts have made this conference a success.

Tapiwa Gundu
SACLA 2024 Program Committee Chair
School of Information Technology, Nelson Mandela University

Organisation

The 53rd Annual Conference of the Southern African Computer Lecturers' Association (SACLA 2024) was organized by the School of Information Technology and the Department of Computer Science, Nelson Mandela University, South Africa.

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Guest Speakers



Guest Speaker 1: Mr Nico Claasen

Title: From Physical to Cyber-Physical - Expectations for AI in Vehicle Diagnostics

Bio

Nico is the Chief Operations Officer (COO) of Wirk (Pty) Ltd., representing Daten- und Systemtechnik GmbH (DSA) in South Africa. Nico has more than 20 years of experience in the manufacturing, automotive diagnostics and software development industries. He has successfully led numerous global teams and projects, showcasing his expertise and leadership skills. An alumnus of Nelson Mandela University, Nico holds Ndiip Electrical Engineering, PDBA (Cum Laude) and MBA (Cum Laude) qualifications. Outside of his professional life, Nico is a devoted husband and father to a daughter. In his free time, he spends far too much time on his retro video game collection.

Short Description of the presentation

In automotive diagnostics there is a noticeable trend from physical systems to cyber-physical systems, highlighting the evolving landscape of modern automotive and software technology. The emergence of the Software-Defined Vehicle is a focal point, underscoring the necessity for innovative approaches to manage the increasing complexity of the modern vehicle.

Five critical challenges for science and research are identified. Using Artificial Intelligence (AI) to improve error detection and handling in complex software, integrating AI and software system monitoring into vehicles, developing AI-driven diagnostic systems for vehicles, utilising cyber systems to diagnose physical systems and implementing remote repair via cyber systems. AI and cyber-physical systems will have a transformative impact on the automotive industry, requiring continued innovation and research to address these emerging challenges.



Guest Speaker 2: Mr Cinga Nyangintsimbi

Title: From Failure to a Team of Fifty

Bio

Cinga is the managing director and founder of BATSAMAYI, a software firm based in Nelson Mandela Bay. BATSAMAYI engineers bespoke software solutions. BATSAMAYI was established as a third-year project group during Cinga's time as a student at Nelson Mandela University in 2013, where he later became a student assistant and consequently started lecturing final-year Information Technology students and assisted as a project supervisor while continuing to build BATSAMAYI. Today, BATSAMAYI has a team of over 50 young software professionals, most of whom graduated from Mandela University and specialises in software engineering, quality assurance and cloud services, as an Advanced Tier AWS Partner.

Short Description of the presentation

He will be speaking on the BATSAMAYI Journey - from its establishment during Cinga's time as a student at NMU in 2013, up to the present day, with a Team of over 50 young software professionals, most of whom graduated from NMU.



Guest Speaker 3: Mr Tony Parry

Title: Engagement and Collaboration in the ICT Association space

Bio

Anthony (Tony) Parry is the Chief Executive Officer of IITPSA (Institute of Information Technology Professionals South Africa – formerly Computer Society South Africa) – a position he has held since June 2007. He represents the Institute on the International Council of the Skills Framework for the Information Age (SFIA) and is a current member of the Advisory Boards of both the Department of Computer Science and the Faculty of Engineering, Built Environment and Information Technology at the University of Pretoria, as well as of the Industry Advisory Board of the School of Electrical and Information Engineering at the University of the Witwatersrand. He has been involved in the SA ICT profession for more than thirty-five years, beginning as a Junior Analyst / Programmer with Standard Bank, and then spending around eighteen years with the Barloworld Group, ending up as a Divisional Chief Information Officer. Tony has had some part-time academic lecturing exposure, having previously contracted to UNISA’s School of Business Leadership on their online MBA programme at the time and thereafter to Wits Business School on PDM, PDBA and MBA programmes. He has held board-level positions in various companies since 2002. He holds a Master’s degree in Business Administration from Henley in the UK and he is a member of a number of professional bodies, including IITPSA (Fellow and Professional Member), the Institute of Directors in Southern Africa (Fellow) and the American Association of Computing Machinery (Professional Member).

Short Description of the presentation

It will be a short introduction on the topic to contextualise it, followed by engagement with the delegates on the matter, for their input – seeking common ground and value-add.

Program

SACLA 2024 Conference Programme

The Boardwalk Hotel in Gqeberha

Wednesday, 17 th July 2024		
12h00 to 17h00	Registration (Front Desk)	Boardwalk Hotel Conference Centre Foyer
14h00 to 17h00	HoD symposium (meeting of HoDs and subject groups)	The Courtyard Hotel
17h00 to 18h00	SACLA Executive Committee Meeting	The Courtyard Hotel
19h00 to 21h00	COCKTAIL WELCOME FUNCTION Boardwalk Hotel	
Thursday, 18 th July 2024		
08h00 to 17h00	Registration (Front Desk) [Coffees on arrival]	
08h15 to 08h25	Venue A: Welcome/Opening [ALL]	
	Venue A: Session 1 Session Chair: Prof Nicky Mostert	Venue B: Session 2 Session Chair: Dr Tapiwa Gundu
08h30 to 08h55	6 - Theresa Banda and Gwamaka Mwalemba Implications of Incorporating Design Thinking in Information Systems Courses	28 - Mark Brand, Jean Greyling and André Calitz Inquiry into the Paradox of an ICT Skills Gap
09h00 to 09h25	7 - Kwanele Mgadleni and Gwamaka Mwalemba The Current State of Information Systems Education in South Africa: A Systematic Literature Review	34 - Adriana Steyn, Funmi Adebesein and Nita Mennega. Empowering Business Students for the Fourth Industrial Revolution: A Hands-On Pedagogical Approach
09h30 to 09h55	22 - Ifeoluwapo Fashoro, Lee-Anne Macpherson and Yu-Qing Fang Interactive E-learning Tool for an ERP module using Sage Evolution	37 - Marie Hattingh, Lizette Weilbach, Riana Steyn, Funmi Adebesein, Nita Mennega, Deborah Oluwadele and Timothy Adeliyi. Bridging the Gap: Towards a Hybrid Approach in Systems Analysis and Design Education
10h00 to 10h25	COFFEE BREAK	
10h30 to 10h55	Venue A: GUEST SPEAKER – BATSAMAYI – Cinga Nyangintsimbi (MD)	
	Venue A: Session 3 Session Chair: Prof Lynn Fatcher	Venue B: Session 4 Session Chair: Dr Kevin Kativu
11h00 to 11h25	9 - Marisa Venter and Lizette De Wet The Influence of Player Type on the Motivation of Students in a Gamified Programming Learning Environment	17 - Andre Calitz and Margaret Cullen The Development of a new Hospitality Management Information Systems module using ChatGPT
11h30 to 11h55	10 - Pakiso Khomokhoana Leveraging strategies used in teaching theoretical Informatics subjects to CSI and Business Students	29 - Carolien van den Berg and Belinda Verster Bridging Local Realities and Global Goals: Exploring Student-Led Sustainable-Smart
		Innovation Projects in a Marginalised Community
12h00 to 12h25	16 - Phumezo Ntlatywa Integrating Interdisciplinary Perspectives in an Information Security Classroom: A Strategy to Foster Collaboration Among the Students of Communication Networks, Software Development and Support Services	49 - Dimitrius Keykaan Towards Integrating ethics into computing curricula: An active learning and cognitive psychology approach

12h30 to 13h25	LUNCH BREAK	
13h30 to 13h55	Venue A: GUEST SPEAKER – IITPSA – Mr Tony Parry (CEO)	
	Venue A: Session 5 Session Chair: Prof Mariana Gerber	Venue B: Session 6 Session Chair: Dr Sue Petratos
14h00 to 14h25	11 - Imelda Smit A Model towards enabling Tutors to fulfil a role in attenuating source code plagiarism	12 - Rouxan Fouche and Liezel Nel. Bridging the Digital Divide: Assessing the Impact of a Community-Focused Service-Learning Project
14h30 to 14h55	19 - Lynn Fatcher, Kerry-Lynn Thomson, Reinhardt A Botha, Noluxolo Gcaza, Tapiwa Gundu and Kevin Kativu. Deconstructing Constructive Alignment: The Design of a Postgraduate Diploma in Cybersecurity	45 - Janet Liebenberg Pair programming and underrepresented groups in Information Technology
15h00 to 15h25	25- Noluxolo Gcaza, Kevin Kativu, Tapiwa Gundu, Lynn Fatcher, Kerry-Lynn Thomson and Reinhardt Botha. Reflections from the Inaugural Year of the Postgraduate Diploma in Cybersecurity: Towards Continuous Improvement	46 - Sithandwayinkosi Goba-Hlongwane, Ronel Callaghan and Jean Greyling Preparing Foundation Phase teachers in KZN to teach coding
15h30 to 15h55	COFFEE BREAK	
	Venue A: Session 7 Session Chair: Prof Bertram Haskins	Venue B: Session 8 Session Chair: Dr Ife Fashoro
16h00 to 16h25	5 - Imelda Smit and Linda Du Plessis Navigating the Integration of Chatbots in Education: A Case Study on Source Code Plagiarism	14 - Gontlafetse Mosweunyane, Edwin Thuma, Onalenna Makhura and Nkwebi Motlogelwa Investigating Automatic Grading of SQL Queries using String Similarity Measures
16h30 to 16h55	40 - Andre Calitz and Margaret Cullen ChatGPT Performance on CS and IS Course Examinations	39 - Tiou Ramabu, Ian Sanders and Marthie Schoeman. A SOLO-adapted evaluation methodology for the generation of learning transitions on the algorithms
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Friday, 19th July 2024		
08h00 to 12h30	Registration (Front Desk) [Coffees on arrival]	
08h30 to 08h55	Venue A: GUEST SPEAKER - WiRK/DSA - Mr Nico Claassen (COO)	
	Venue A: Session 9 Session Chair: Prof Kerry-Lynn Thomson	Venue B: Session 10 Session Chair: Mrs Janine Nel
09h00 to 09h25	35 - Pakiso Khomokhoana and Tlholohelo Nkalai Cognitive processes used by Students in understanding Aggregation and Composition in UML: A Case of First-year BCIS Students	44 - Rudi Serfontein, Henri Van Rensburg, Lynette Drevin and Gunther Drevin. Reflective Analysis of the Impact of an Induction Programme for Honours in Computer Science and Information Technology Students
09h30 to 09h55	36 - Marli Swanepoel, Machdel Mathee, Marié Hattingh and Lizette Weilbach Enhancing UX in Learning Management Systems: Leveraging Design Thinking for the Development of Chatbot Design Principles	53 - Xolile Zepe and Sue Petratos Digital Literacy: Challenges and Opportunities
10h00 to 10h25	54 - Fezile Matsebula and Ernest Mnkandla Exploring Student Expectations of Learning Analytics in South African Higher Education	33 - Imelda Smit, Lynette Barnard and Dieter Vogts. Elements to Address in a Computing Research Project Honours Course Module: A Tale of Two Universities
10h30 to 10h55	COFFEE BREAK	
	Venue A: Session 11 Session Chair: Mr Vuyo Mduyvelwa	Venue B: Session 12 Session Chair: Prof Dieter Vogts
11h00 to 11h25	8 - Nomabhongo Masana Usage of a Learning Management System for Assessments in Higher Education: A Scholarly Personal Narrative	38 - Michael de Jager, Nicky Mostert, Bertram Haskins and Cheryl Schroder Balancing Acts: Reflecting on the Workload and Academic Burnout in Software Development Project-Based Learning Modules vs. Traditional Modules
11h30 to 11h55		30 - Nombuso Sibeko, Ijeoma Noella Ezeji, Chinaza Uleanya and Matthew Adigun Reflections on Leading and Managing Computer Science Final Year Projects in a South African Rural University using Gibb's Framework
12h00 to 13h00	Venue A: SACLA 2024 AGM (All delegates to attend)	
13h00 to 13h15	CLOSING and THANKS	
13h15 to 14h15	LUNCH BREAK	

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Leveraging strategies used in teaching theoretical Informatics subjects to CSI and Business Students

Pakiso J. Khomokhoana^[0000-0003-3642-1248]

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Abstract. The inter-curriculum needs at the tertiary level lead to Business students finding themselves grouped and taught together in the same class with Computer Science and Informatics (CSI) students. This practice creates problems for instructors teaching a combination of these students as they have diversified backgrounds. It is, therefore, necessary for instructors to be aware of this diversification so that they can meet the learning needs of all students they teach. As such, instructors must leverage strategies that help both CSI and Business students to improve their motivation, engagement, and performance not only in practical, but theoretical modules as well. The aim of this study was threefold. *First*, to identify the teaching and learning strategies that can be used in teaching theoretical modules to CSI and Business students. *Second*, to identify areas of these strategies that need to be improved, and how to equally benefit CSI and Business students. *Third*, to use the insight into these strategies, and recommend better ways for instructors to teach theoretical modules to both CSI and Business students. This study followed an integrated methodological approach where data was collected through asking questions (individual semi-structured interviews). Thematic analysis of the collected data revealed seven key pedagogical strategies that participants found instrumental in helping them master content for a theoretical informatics module. Engaging further with these findings, relevant recommendations on leveraging these strategies were made.

Keywords: Theoretical computer science, computer science education, pedagogical strategies, theoretical module teaching, CSI students, Business students.

1. Introduction

It is generally challenging to teach subjects of a theoretical nature in all disciplines [14, 17, 23, 30]. The challenge is rife in the Computer Science and Informatics (CSI) discipline because students are more used to the practical components of teaching and learning [21, 22, 25, 52]. This becomes even more challenging when Business students are mingled and taught together with CSI students, especially in theoretical modules. As such, instructors may have to employ pedagogical strategies that encourage students to effectively engage with the learning content so that they can perform well in the subject. Ignoring this may lead to a high failure rate which may not be fair if students pass practical subjects, but are held back from progressing to the next levels of study by theoretical subjects. Similarly, it is challenging to teach students a subject that they believe is not mainstream in their programme of study. A case in point being students who come from the Business stream to take CSI modules as part of the Computer Information Systems programme (e.g., inter-curriculum).

The challenges alluded to in the previous paragraph are particularly experienced in institutions that have not yet divorced the Computer Science programme from the Computer Information Systems programme because the composition of students in some modules brings a lot of diversity in terms of skills that students possess. This diversity requires instructors to be aware of it and ensure they speak a language that is equally understood by many students. Otherwise, unsatisfactory performance is highly likely to be witnessed if this diversification is or can be overlooked. Another challenge with this diversification is that the backgrounds of students who are put in the same class and are taught and assessed using the same scale are not the same. For example, it may be easier for students with a Computer Science background to better understand the technical jargon/concepts than Business students. In summing up this challenge, Robins (1988, as cited in [52, p. 319]) asserted: “*Theoretical computer science has an awful reputation among undergraduates ... I have heard many resentful undergraduates describe this course using terms such as dry, boring, unmotivated, contrived, impractical, and too abstract. Interestingly, those very few students (usually those who excel in the material) describe it as elegant, challenging, practical, and stimulating*”. Robins’s assertion was later supported by several other authors such as Enström [21] and Hamalainen [25]. As such, it is key to be aware of, and understand pedagogical strategies used to teach, not only practical but theoretical modules also, to CSI and Business students who are put in one class. This paper, therefore, attempts to answer the research question: How can theoretical modules be effectively taught to CSI and Business students grouped in the same class? To fully answer this question, it was broken down into the three subsidiary questions as follows:

- What are the pedagogical strategies that can be used in teaching theoretical modules to CSI and Business students?
- What areas of these strategies need to be improved and how to equally benefit CSI and Business students?
- What can instructors learn from these improvements?

In the remainder of this paper, a literature review reporting on pedagogical strategies in teaching theoretical modules is presented in Section 2. This is followed by a discussion of the research design and methods in Section 3, and results and interpretation in Section 4. A discussion of the study findings is presented in Section 5, while Section 6 concludes the paper.

2. Literature Review

Tailored for theoretical modules, instructors can use various pedagogical strategies to leverage student motivation, engagement, and performance. These include but are not limited to strategies presented in the paragraphs that follow.

To aid the comprehension of technical and theoretical concepts in various disciplines including Computer Science, strategies such as highlighting, underlining, and colour coding have been used and proven effective [24, 27, 50]. Colour coding is cited as a strategy that instructors ignore most of the time irrespective of the impact that it can have on the learning of students [56]. The use of ‘warm’ colours (e.g., red and yellow) [42] in the teaching can help boost student cognitive focus and concentration, and students can benefit maximally in terms of remembering the learned ideas and concepts [7, 18, 20, 32, 48]. Although some studies associate the highlighting strategy

with low effectiveness [19], it has the potential to be an instrumental strategy [8, 41] in learning and understanding theoretical concepts.

Additionally, the use of visual cues is regarded as a strategy that not only visual learners can use, but non-visual learners also, as such cues facilitate effective learning not only in Computer Science, but in other disciplines too [58]. Another valuable strategy that instructors in different disciplines can use, not only to help students have a correct and deeper understanding of theoretical concepts but be able to think critically and solve problems as well is the use of diagrams, pictures, or explicit visual illustrations [31, 54, 55]. Furthermore, the contextual learning framework extensively draws on real-world tasks and situations. Through this contextualisation, students can better understand the learning concepts, whether theoretical or not, and can retain the knowledge beyond their studies [43]. Some authors [16, 36] believe that when instructors make learning relevant to the real world, students can make important connections and see that the learning process does not occur in isolation.

Learning also happens through repetition. However, too much repetition may have a dark side (e.g., waste of time, boredom, anxiety, etc) for other students who already understand the work [2, 3, 10]. Exposing learners to a range of suitable examples is another useful strategy that broadens and deepens the learning process [1, 22]. In providing examples, it is recommended to start with the simple ones that likely resonate with most students, and then move on to the more complex ones [37]. Furthermore, there is an ongoing debate on whether instructors should at all share lecture slides with students [57]. However, considerable research shows that the sharing of lecture slides before class is a helpful strategy for students in terms of class preparation [5, 9, 49].

Moreover, mnemonic instruction is cited as a strategy that enhances students' learning across various disciplines, be it practical, theoretical, or otherwise [6, 33, 47]. According to Mohammed et al. [40], mnemonics use tools such as retrieval cues to encode some information in a way that allows for efficient storage and retrieval. These cues can help learners to (re)organise information and retrieve it easily and in some order from their memory [33]. Of the various types of mnemonics such as pegword rhyming and keyword, acronym mnemonics are the most widely used mnemonic strategies. Using this method, learners use the first letter of each word in a phrase to form a new word or phrase that is easier to remember [45].

3. Research Design and Methods

3.1. Design

The design of this study was narrative in nature based on an integrated-methods research approach grounded on Frameworks for an Integrated Methodology (FraIM) [46]. As a type of mixed methods design, FraIM suggests that no philosophical position needs to be adopted before starting the study. However, such a position can be adopted as the study evolves or during the interpretation of results. In this study, narrative data was collected by asking questions. The study population consisted of second-year Bachelor of Computer Information Systems (BCIS) students from a South African university. The sample for this study consisted of 16 students who voluntarily agreed to participate in the research activities. The sample was selected both purposefully [53]

and conveniently [39]. The sample was purposeful because the students were registered for a module in which they were taught using various strategies to help them leverage their motivation, engagement, and performance. The sample was also convenient as the researcher had easy access to the participants as he was the lecturer for the selected module.

3.2. Data collection

Based on the 'asking questions' data collection strategy, primary data was collected using individual interviews. Each interview had both close- and open-ended questions on the experiences of students about the pedagogical strategies that were used in teaching them a theoretical module. Apart from the specific questions that students were asked, there were also probing questions that were asked when necessary. The interview proceedings were audio-recorded with permission from the participants.

3.3. Data analysis

To transcribe and analyse the audio recordings from the interviews, Creswell and Creswell's [15] approach was followed. Upon transcribing the data, it was cleaned by finding faults and correcting them accordingly [13]. As the questions were open-ended, the transcripts had several statements that were illogical and repeated. As such, fuzzy validation was applied instead of strict validation. In using strict validation, a researcher must completely remove invalid responses [44]. In using fuzzy validation, a researcher is permitted to correct some data if there is a reasonably close match to a known correct answer. After cleaning the data, familiarisation with it [34] was done by listening and re-listening to the audio records as many times as possible and by thoroughly and repeatedly reading the transcripts. From this familiarisation, a coding plan was drawn up. This helped guide the analysis of the data to address the study's research questions. At this stage, the 16 validated transcripts were imported into the NVivo tool. Codes for the pedagogical strategies that were emerging in the data were then developed. To code effectively, researchers can use units of analysis which may include words, sentences, or paragraphs [29]. As such, data was coded by marking text (e.g., highlighting, underlining, circling, and annotating) within the confines of the stated units of analysis. The codes created were then populated by linking them with the complementary segments of text. In this refinement process, the names of the codes were constantly revised until suitable themes emerged. The frequency of occurrence for each emerging theme was considered.

4. Results and Interpretation

Analysis of the data collected revealed seven pedagogical strategies that participants found instrumental in helping them master content for the theoretical module they enrolled in. These strategies are presented in the order from the most to least occurrences.

4.1. Content highlighting

Content highlighting refers to marking the learning content to stand out or draw attention from the rest of the other content [19]. This can be achieved through colour coding and isolation effect. The isolation effect is a strategy that uses salient attention

cues such as underlined, capitalised, italicised, bold, and typeface text [4, 28]. Based on the view shared by Mickols and Wippich [38], content highlighting was broken down into colour coding and isolation effect.

Colour coding: In agreement with the literature [24, 27, 50], students appreciated the use of colour as a pedagogical strategy, and they associated it to be playing a key role in helping them identify and remember important theoretical content that they had to learn. This strategy was observed with thirty-five occurrences from all the 16 study participants. For example, P13 (participant 13) attested: *“You'd have the whole information of the concept and then you would put certain key points in red or in green, and then that would help me remember the rest of the pointers in that slide”*. P9 was specific to indicate that colours convey a certain degree of importance of the learning content marked with colour. For instance, content marked with red is more important than content marked with other colours as according to Diachenko et al. [18], the red colour sends strong emotions. In this regard, P9 confirmed: *“I would know that this thing is important, especially the different colours, maybe red or blue. So, the red would say this one is more important”*. Visual learners also indicated that the learning content marked with colour resonates with them more than content not marked with colour. In this regard, P15 noted: *“The one that stood out for me as someone who is a visual learner is that your slides were colour coordinated and then our slides were not colour coordinated. And I was like, I wonder why our slides aren't colour coordinated. That is a number one strategy ... and the ones that have colour communicate to me better”*.

Other students indicated that the colour coding strategy helped them in their assessments. This strategy specifically helped P4 to correctly answer the question on virtualisation within a very short space of time: *“I think we were asked about virtualisation ... I spent 5 seconds on the question because if I still remember, I think it was red on the slides ... it really helped”*. P15 was able to answer the voltage question correctly: *“There was how much voltage the components used? I remember that colour was in blue”*. Additionally, P11 indicated that the strategy helped him as well with the flow of learning content: *“It also helped with the flow of the content because usually in the slides, the things that are related to each other are coloured the same”*. Moreover, it is also key to note that some students may have issues with this strategy as P8 indicated that he personally has problems with the orange colour: *“I don't notice the orange colour. So I don't think you've ever used the orange colour”*. This implies that it could have been an inconvenience to him if the orange colour was among the colours that were used in the teaching.

Isolation effect: For this study, the isolation effect strategy includes only the use of italics and bold text [4, 28]. This strategy was observed with 32 occurrences from all the 16 study participants. The participants believed that this strategy helped them a great deal to understand the work covered in a CSI theoretical module especially because it guides their cognitive focus [26] and helps them to identify important information to focus on for the purposes of assessment [12, 35, 51]. Pieces of evidence in this regard are provided below:

“When you highlight it, you give us hints that these are the things that might come in an assessment. I look at it in that way when I see highlighted things. I'm like, this might come in an assessment if it's highlighted. I also study things that are not highlighted, but I focus more on those that are highlighted” — P6.

“When you did highlight, you mostly highlighted the important parts that we need to learn. I don't want to say the other parts are not important, but mostly it was the very most important parts that you wanted us to understand” — P8.

It is key to note that students are aware that they do not only have to focus on the highlighted content, but the other content as well, as P6 indicated that he also studies the content that is not highlighted. P6 is the student who was the top of the class at the end of the semester with a final mark of 94% and was a business student. However, under stringent time, stress, and assessment conditions, students resort to studying only the highlighted content. In this regard, P13 stated: *“If I could see that I wasn't going to be able to memorise every single thing, I focused on what was highlighted”.*

One other key revelation in the data is that students do not instantly see the importance of highlighting some learning content but do so at a later stage. In this regard, P1 reflected: *“I think we don't realise that, by you highlighting specific content, there was a reason behind it ... but once I came for consultation, that's when I realised, ouh, there's a reason behind highlighting this content because it is the key information that I should know from this chapter or topic”.* This finding calls for instructors to explicitly explain all the teaching strategies to students before their application.

4.2. Use of diagrams/pictures

It was overwhelming to see the value that students attached to the use of diagrams/pictures strategy in teaching the CSI theoretical module. This finding is in agreement with several authors who have used diagrams or pictures in their pedagogy [31, 54, 55]. Twenty-nine occurrences of this strategy were observed in all 16 study participants. As part of evidence on how students felt about teaching a theoretical module using diagrams, P1 noted: *“When they talk about grids, you don't know the picture that they're talking about. So, I think it helps to see the picture and then also put the words. ... I've never seen a blade. I don't know if that thing was a blade, and I would have never taken the initiative to go check how it looks like”.* It is a key revelation to notice that had only the definition of a blade given, nothing would have triggered P1 to go further into checking for herself what a blade looks like in a picture/diagram. Another key finding is that a picture makes students understand concepts instantly such that others do not even bother to look at the textual definitions as shared by P2: *“You remember the three-tier, the two-tier, the one-tier diagrams ... I could differentiate them by just looking at the diagram itself”.*

Visual learners also reap good benefits from instructors who use diagrams/pictures to explain some learning concepts. In this regard, P4 pointed out: *“For me, I'm a visual learner and when I see something, it's easier for me to remember it. Even on some of the slides, you put pictures there, those pictures helped me a lot because sometimes even in the text I see the picture and I am like, yeah, I know this one”.* Using not only one diagram or picture is also seen by other students as bringing different perspectives to the understanding of the concepts under discussion. For example, P9 recollected: *“We used to have pictures of the concept that we were discussing. Those pictures were really helpful because they were not only one, but a lot of them in different perspectives”.* On the contrary, P11 shared his frustration with using more than one diagram to explain a concept:

“Having a lot of diagrams was sometimes good, and sometimes it was bad. For example, sometimes you can see, let's say you were explaining a cluster — you see the

first one, and automatically you understand what's happening. Then you move on to the second diagram, it's something completely different, and you're lost. So, sometimes it helps, and sometimes it was confusing because I remember with that one specifically of a cluster. I know clusters because I've worked with a cluster before, but that question tripped me when it came to a class test. I think you showed us a diagram of a cluster and you asked - Is this a cluster? My answer was no because there were too many different variations of the same thing that I ended up getting confused”.

4.3. Relating concepts to the real world

Relating learning concepts to the real world does not only help Business students to understand and master theoretical concepts, but CSI students as well. This helps students in that they can make the necessary associations between and among various theoretical concepts [16, 36]. Twenty-three occurrences of this strategy were observed in 14 participants. P1 particularly remarked:

“You would take technological terms and bring them to real life, hence making it easy for students like me who's more focused on business studies ... for example, with the signal-to-noise topic where you said if I am the lecturer and the student is sitting at the back, obviously the one sitting in front has a better chance of hearing what I'm saying than the one sitting at the back — that makes sense. Now the technological terminologies and the concepts are made way easier to understand because they are brought down to something that we are all aware of and something that we can all relate to. So, I think that also helped a lot”.

The contents of the above excerpt are related to the message transmission topic and factors that can distort the message during transmission [11]. Concerning how messages are transmitted, P7 said: *“It can fit in that when you're sending a message, you obviously have someone who wants to send a message so that it's delivered and then a person who will receive that message — so that's the post office. And that could be like your router or your switch or your hub that knows where this message needs to be delivered”.* This implies that the student might have been able to understand the characteristics of hubs, switches, and routers when the lecturer taught that a hub is a dumb device, a switch is a semi-intelligent device, and a router is a fully intelligent device. These are technical concepts, but even Business students were able to grasp them relatively easier as a result of using the scenario of posting a letter through the normal post office (which is not a foreign concept), where there are sending devices, media through which messages traverse, configuration of the devices transmitting messages, contents (e.g., IP addresses) of the transmitting devices as well as the receiving devices, and what they can do if the message cannot be transmitted successfully.

About the discussion of memory allocation [11], P9 shared: *“I understood it the second time around, because the first time it was a little bit blurry, and then the second time around I got it”.* The first instance was when the lecturer explained that when declaring an array, the Operating System (OS) starts to reserve or allocate memory for the number of elements to be stored in the array. The second instance was when the lecturer explained that when opening a Microsoft Word file, the OS knows that it needs to allocate memory for the contents that will be added to the document. The first instance resonated better with the CSI students, while the latter was more relatable to Business students. Moreover, gestures that the lecturer made while discussing the

modulation techniques helped some students to fully understand and not easily forget the concepts. For example, to determine how the graph for the multi-level coding has to be drawn (whether it goes in the negative or positive direction), the lecturer physically walked forward (+) and backward (-) in class to demonstrate that. In this respect, P7 recollected: *“A real-world example was for multi-level coding. I think it was for frequency, where you know how and when the signal is changing from one to zero, it goes in different directions. So, the example that you made is that I think it's been one where you were walking forward and backward”*.

4.4. Repetition

Although participants did not share the same views when it comes to using repetition as a teaching strategy, it was identified by many to be a useful strategy in their learning of a CSI theoretical module content. Eighteen occurrences of this strategy were identified in 11 participants. P4 indicated that learning through repetition makes her not to forget the learned concepts easily: *“For me personally, I feel like repetition is the best way for me to learn. If I keep saying it, it gets stuck in my mind even if it's hard, I would never forget it”*. Irrespective of its usefulness, the other participants shared their frustration with the repetition strategy:

“When I do understand the concept and you keep on repeating that same content all over again, at some stage I'm going to zone out” – P11.

“Repetition also created a sense of information overload. So, it was like you explained it, and then you explained it, and then maybe the third explanation, I started to doubt if I actually understood what we were talking about” – P13.

“If you made the first example for me, I was able to grasp it. But when you make the second example, I've lost my attention. ... and probably just because I'm in front of the computer, I would just start playing games” – P16.

As can be seen in these excerpts, the repetition strategy causes anxiety, frustration, and anger, and it encourages student disengagement [2, 3, 10]. However, to accommodate both CSI and Business students, it was a necessary strategy to use as shared by P13: *“I feel like it wouldn't be fair to be frustrated because even if I understand, I'm not the only student in class, and just because it may not be working for me and my learning style, doesn't mean that it's not effective”*.

4.5. Use of examples

In line with Alford and Griffin [1] and Filos-Ratsikas [22], the participants appreciated the fact that the lecturer always made at least two examples (one for CSI students [normally the first], and another for Business students [normally the second]). This strategy was necessary as it was not always easy for Business students to understand technical examples that CSI students could easily understand. The strategy was identified in 13 participants with a total of 15 occurrences. Pieces of evidence for this strategy are provided below:

“You'd always try to use very practical examples ... so that would help us understand some concepts” – P13.

“The other example was when you were explaining virtualisation, that let's say we're in an office and we all share this printer. So, we're not necessarily aware that we're sharing it with other people. We just think it's ours and that we own it” – P7.

“So the lecturer made a point that he was accommodating both Business and CSI students by giving examples that accommodate both groups ... you gave us a lot of examples that when I didn't understand one example, I would understand other examples ... so when you explained them [concepts] using the business side, it was clearer compared to the Computer Science side” — P9.

Although P6 appreciated the use of examples, she was quick to point out the disadvantage that comes with always making examples: *“It's always important to hear all the extra information you have especially with giving examples for those students that don't have the technical background. But it was a disadvantage in terms of time also”*. P6 might have shared this disadvantage because she was a CSI student, and she already understood the first technical example. It was also key for P3 to notice that it was not easy for the lecturer to juggle either examples or explanations of concepts: *“In class, one thing I noticed was that with explaining the concept, ouh, I could see it was very difficult. But I feel like you did your best in trying to explain the concepts in a way that even students without the technical background/foundation can understand the concepts”*.

4.6. Sharing of lecture slides before/after class

The participants liked the fact that the lecturer shared the general lecture slides before class discussion on a topic, and those that were content highlighted (see Section 4.1) after the discussion of the topic. This finding is consistent with the literature [5, 9, 49]. Fourteen occurrences of this strategy were identified in seven participants. The following excerpts provide evidence:

“I think it does help a lot because it makes our content a bit easier to understand because if you take the first one [normal lecture slides] that you send maybe a week before, that one is just for us to go through the notes to understand” — P6.

“The lecturer would not send the updated slides beforehand. He would send them after, so we would do the slides that are not updated in class and then after that, that's when he would send the updated ones” — P12.

Irrespective of this strategy being regarded as useful, P5 and P15 indicated that they did not bother to work on the slides before class. P5 remarked: *“I think the sharing of the notes beforehand is important, although I, personally, didn't necessarily go through the notes before you went through them in class. But I think it's important for students who want to put in extra work, I think that's a great technique”*, while P15 admitted: *“Personally, I won't lie, I did not look at the slides before class. I would look at the slides while in class”*. These students might have been some of the brighter students as they both came from the business side, but they ultimately got 74% and 73% respectively as their final marks for the module irrespective of them not bothering to work on the shared lecture slides before class.

4.7. Use of acronym mnemonics

Although the use of acronyms was not commonly used by the lecturer in teaching the theoretical CSI module, participants observed it as one of the strategies they liked and even use in their own learning. This finding is in line with the literature findings [6, 33, 47]. Ten occurrences of this strategy were identified in seven participants. Typically, P1 recollected: *“You would give us acronyms with the PDNT/SPA”*, and P10 affirmed: *“I wasn't familiar with that strategy [use of acronyms], but I liked it”*. In

discussing the OSI reference model, the lecturer used the acronym [45] PDNT/SPA (P – Physical, D – Data link, N – Network, T – Transport, S – Session, P - Presentation, and A – Application) to help students to be able to remember the seven layers of the OSI model in an arranged order should the assessment question ask them for that. P11 identified this strategy as well, but he was quick to share his specific challenges with the strategy:

“I remember that strategy of using the acronyms. My problem with that strategy specifically is that it required me to cram the acronym. If I crammed it and I forget one [what one letter stands for], I'm going to end up forgetting everything. So, the way I approached it, I was trying to link certain words in the definition with the concept itself” – P11.

When asked to elaborate on what he meant by linking words to concepts, P11 used an example of Secure Shell (SSH) and Common Object Request Broker Architecture (CORBA) where he reflected: *“With SSH, I understand the concept itself, but with CORBA, I don't understand it”*. This means that the student would be comfortable using the acronym strategy for SSH, and not for CORBA as he considered it a foreign concept. CORBA might have sounded foreign to the student because it might have been his first time coming across the concept in a second-year CSI theoretical module, while he might have come across SSH many times in his previous years' CSI modules.

5. Discussion of Findings

This study has uncovered several key findings concerning the pedagogical strategies that instructors of Computer Science theoretical modules can apply to help close the gap that exists between CSI and Business students. Overall, instructors need to utilise these strategies if they teach theoretical modules and have students with diversified backgrounds in the same class. This may be helpful because it is also not a feasible option to teach the two groups separately due to a shortage of resources. Similarly, teaching only CSI students would lead to some of them not understanding the theoretical concepts well since the use of both technical and real-world examples makes them understand the content better or helps them confirm their original understanding.

Another argument for not teaching Business students and CSI students separately could be the angle that if Business students are taught alone, they could probably be channelled to the business mindset, whereas they should be put to the Computer Science/Information Systems mindset. This may be witnessed in instances where they ask questions that may resonate with almost all students if they come from the same stream. At the same time, it would not make a lot of sense to teach deeply technical content if Business students are taught alone as many of them would not easily grasp the content. Another problem with teaching the groups together would be that others, especially Business students might feel like the content is being rushed if other students from the CSI stream readily understand the work. It was also key to recognise that it would be more instrumental for instructors not to use the teaching strategies on the assumption that students will readily understand them and the rationale behind using them (such as highlighting), but these strategies should be discussed with students before using them in the teaching process.

Furthermore, it was key to realise how useful content highlighting was in helping students, not only to understand theoretical content, but also with the flow of the

learning content and to be able to recall information easily during assessments [12, 35, 51] as a result of the colour and cues such as bold and typeface text [4, 28]. It was further key to reveal that instructors should not use colours [24, 27, 50] bluntly in marking the learning content, but should be careful in their choice as some students may experience problems with some colours due to challenges such as health, gender, and individual preferences. Another key revelation was to notice that the use of diagrams/pictures [31, 54, 55] benefits students irrespective of whether they are visual learners or not. However, instructors should be careful in using diagrams/pictures so that they do not end up confusing learners.

It was also key to realise the effectiveness of examples integrated strategically into the discussion of the learning content [1, 22]. This integration could be achieved through the use of normal examples and making associations with real-world artifacts [16, 36] when teaching some theoretical concepts. For example, when discussing the message addressing and forwarding [11] concept especially the centralised directory and distributed approach in the selected module, the instructor may explain to students that in a centralised directory, every central node must know the location of one or more directory servers and if a server is moved, all central nodes must update their server location information. The instructor may further explain that in a distributed approach, each central node knows the addresses and physical locations of other nodes on its network and knows other nearby central nodes and the groups of addresses they control. In these instances, CSI students may not find it difficult to understand these concepts at first hand. However, Business students (grouped with these CSI students) may find it challenging to understand these concepts because of their background. As such, one possible way could be for the instructor to tell students that this concept uses the same principle as the 'examinations department' within an academic institution where some question papers must be submitted to this department (distributed approach), while others can be handled within a given department (centralised approach).

Furthermore, instructors should be careful to strike a balance in applying the repetition strategy so that it does not become monotonous to some students [1, 3, 10]. Additionally, it was key to see the value that students attached to the slides that were shared with them, especially those that were shared after class discussion as they had a lot of modifications incorporated in them compared to the normal ones that were shared before class discussions [5, 9, 49]. As the selected theoretical module was not at the first-year level, students were expected to apply their knowledge more than a mere recall of concepts. However, the little use of mnemonic instruction [6, 33, 40, 47] specifically using acronyms [45] was appreciated by the study participants irrespective of whether they were CSI or Business students. While it cannot be conclusively argued that the use of these pedagogical strategies directly led to better academic performance, Table 1 below suggests a possible correlation.

Table 1. Comparison of performance in academic years 2021, 2022, and 2023 for the selected module.

Description	2021	2022	2023
Pass Rate	77.3%	87.9%	89.8%
Distinctions (75% and above)	10.6%	21.0%	16.4%
Pass (between 50% and 74%)	66.7%	66.9%	73.4%
Fail (below 50%)	22.7%	12.2%	10.2%

By integrating these pedagogical strategies into curriculum design, instructional practices, and student support mechanisms, computer science and information systems programs can significantly enhance student engagement, comprehension, and retention. These strategies provide a multi-faceted approach to education, catering to various learning styles and ensuring that students are well-prepared for both academic success and real-world application of their knowledge.

6. Conclusions and Future Research

Due to the inter-curriculum needs at tertiary level, Business students find themselves grouped and taught together in the same class with CSI students. This arrangement introduces challenges to instructors teaching a combination of these students as they have diversified backgrounds. Consequently, instructors need to be aware of this diversification so that they can meet the learning needs of all students they teach. This, among others, could be addressed if instructors were to leverage pedagogical strategies that help both CSI and Business students to improve their motivation, engagement, and performance not only in practical but theoretical modules too. By focusing on the strategies relevant to teaching theoretical modules, the study aimed to first identify the pedagogical strategies that can be used in teaching CSI and Business students; second identify areas of these strategies that need to be improved, and how to equally benefit CSI and Business students; and third use the insight into these strategies, and recommend better ways for instructors to teach theoretical modules to both CSI and Business students.

The thematic analysis of data collected through asking questions revealed seven key pedagogical strategies that Computer Science or Information Systems instructors can use to teach theoretical modules to both CSI and Business students together in one class. These strategies combined with findings from the literature and the personal experiences of the researcher were used in discussing and recommending better ways on how these strategies can be effectively used to benefit both CSI and Business students taught theoretical modules grouped in one class. The findings of this study are valuable to the broader education community that is also tasked with teaching related theoretical modules. However, the limitations of this study include a small sample (n=16). Therefore, natural extensions of this work could be conducted in a different setting, perhaps with more participants from another theoretical CSI module and with a different instructor.

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Bridging the Digital Divide: Assessing the Impact of a Community-Focused Service-Learning Project

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Abstract. Research on the impact of service-learning projects within communities remains limited. This is particularly evident in the case of the Information Technology Service-Learning (ITSL) project facilitated by the University of the Free State in South Africa. Currently, there is a notable absence of community involvement in project decision-making and a lack of formal impact assessment. The study described in this paper aimed to evaluate participant perceptions of the ITSL project's impact and identify areas for improvement. As part of the non-experimental descriptive research design, an online questionnaire was completed by 51 project participants. The findings revealed high participant satisfaction, with many willing to recommend the program to others. Despite limited community input in project planning, participants praised the project, highlighting the scarcity of similar opportunities in the community. The project notably impacted first-time computer users, leading to increased employability for many. One notable finding was that participants struggled to develop new ideas for project improvement. This difficulty may stem from a combination of issues, including a lack of reference points for comparison and a sense of gratitude for the free training provided. The study underscores the potential of service-learning projects to narrow the digital divide in communities. However, it also highlights the need for improved community engagement and consideration of community needs to move this from a community-focused to a community-driven service-learning project. Facilitating discussions through community workshops and focus groups, where all parties contribute equally, is recommended for enhancing project impact and fostering a reciprocal university-community partnership.

Keywords: Community Engagement, Community Involvement, Computer Literacy, Digital Divide, Service-Learning, Service-Learning Impact

1. Introduction

In today's interconnected world, access to digital technologies and proficiency in their use are pivotal aspects of individual and community empowerment. However, alongside the rapid advancements in technology, stark disparities persist in the distribution of digital resources and skills, giving rise to what is commonly referred to as the digital divide [1]. Nowhere are these disparities more acutely felt than in regions marked by economic inequality and limited access to educational opportunities, such as rural South Africa [2].

The digital divide manifests not only in the unequal distribution of hardware and internet connectivity but also in disparities in digital literacy and proficiency [3]. For

marginalised communities, the inability to access and utilise digital tools effectively exacerbates existing social and economic inequalities, hindering opportunities for education, employment, and social participation [4]. In South Africa, the digital divide entrenches patterns of exclusion and marginalisation, perpetuating cycles of poverty and inequality [5].

Recognising the urgent need to address these systemic inequities, the University of the Free State (UFS) embarked on a pioneering initiative aimed at bridging the digital divide within its local community. Situated in the heart of central South Africa, the UFS occupies a unique position to engage with and empower the surrounding communities through innovative educational interventions [6].

The Information Technology Service-Learning (ITSL) project was established in 2015, marking a significant milestone in UFS's commitment to community engagement and social responsibility. Conceived within the Department of Computer Science and Informatics (CSI), the ITSL project sought to harness the university's expertise and resources to provide free computer literacy training to community members. Envisioned as a symbiotic partnership between academia and the community, the project aimed not only to impart essential digital skills but also to empower individuals to navigate the increasingly digitised landscape of the 21st century [7].

At its core, the ITSL project embodied service-learning — a pedagogical approach that integrates meaningful community service with academic instruction, fostering reciprocal learning and social responsibility among students [8]. Through the project, second-year undergraduate students in the CSIS2642 module were tasked with delivering comprehensive computer literacy training to participants from the local community. The curriculum, encompassing fundamental skills in Microsoft (MS) Word and MS Excel, was designed to address community members' perceived needs and challenges in accessing employment opportunities and educational resources. The ITSL project can, therefore, be regarded as a community-focused service-learning project.

Despite the bold goals of the ITSL project, its effectiveness and sustainability were contingent upon meaningful community involvement and engagement. However, as subsequent project iterations revealed, community participation in decision-making remained limited, undermining the impact and relevance. Additionally, the absence of formal mechanisms for evaluating the project's impact hindered efforts to identify areas for improvement and optimise outcomes [9]. Consequently, the study described in this paper aimed to evaluate participant perceptions of the ITSL project's impact, focusing on their satisfaction with the project, the project's effectiveness, and to identify areas for improvement in future implementations. In addressing this aim, the paper seeks to answer the following research questions:

- To what extent are the participants satisfied with the ITSL projects' delivery and outcomes?
- What are the perceptions of participants regarding the effectiveness of the ITSL project?
- What recommendations do participants have for improving future implementations of the ITSL project?
- How can community members be more effectively involved in decision-making processes regarding future ITSL projects to ensure its relevance and sustainability?

2. Background

2.1. Lack of Community Involvement in Service-Learning

Community engagement has undergone significant conceptual development as researchers have delved into its value and methodologies across various settings. A growing body of literature explores the importance of collaboration and partnership between universities and their community engagement endeavours [10]. This shift in perspective acknowledges that community engagement should not be a one-sided process, as reciprocal learning opportunities are inherent in such engagements [11]. This evolving understanding now contributes to the broader knowledge society, where students and academic staff can apply theoretical concepts to specific local contexts. In the South African context, community engagement serves as a means to develop indigenous knowledge systems, allowing for a deeper understanding of local knowledge and facilitating the production of knowledge relevant to African contexts [12].

As one of the community engagement pedagogies, service-learning combines learning goals and community engagement in ways that can enhance student growth and the common good. The service-learning pedagogy integrates meaningful community engagement with instruction and reflection to enrich the learning experience [13]. Service-learning projects typically give students direct responsibility and real-world accountability to people and organisations who genuinely need their services [8]. Community engagement through service-learning is generally incorporated into a course or series of courses through a project with learning and community action goals [13]. Such projects can be described as community-focused service-learning projects.

It is emphasised that community-based research is research with, rather than on, communities [14]. Lall [15] supports this notion by stating that such research entails co-creating knowledge through examining community issues in all their complexity as an inter-related research exercise. To achieve this relationship, community engagement requires a community needs-led approach, starting from where the community is rather than imposing ideas from above [16]. Multimedia-based curricula and pedagogy should, for example, be developed and implemented using local content to make the material acceptable to the community [17].

Mahlomaholo and Matobako [18] claim that university-community engagement through service-learning fails to affect community change because insufficient attention is paid to honest engagement (e.g. listening to the community, enhancing local resources, and critiquing power relations). Emphasis should instead be placed on the issue of mutuality, where all partners contribute to the shared pursuit of sustainable solutions to challenges and service needs and implement a mutually agreed-upon strategy in order to foster a community-driven engagement [19]. Trust and reciprocity between all constituencies are core elements of a constructive partnership. Evaluations of such work in South Africa suggest that these parameters are not always in place.

The purpose and mission of community engagement and service-learning are not without their critics. Evaluations by the South African Higher Education Quality Committee (HEQC) [9] highlight inadequate impact assessment on institutions' communities. When researchers and practitioners focus on impact, they find it

challenging and often default to measuring quantity over quality, whether intentionally or not. The work of service-learning is complex and multidimensional since it depends on a community-university collaboration in which all parties identify shared goals and have distinct perspectives. Nevertheless, all too often, the assessment of service-learning courses is limited to documenting hours of service or collecting journals, or, in worst cases, no assessment is conducted [20].

There remains a surprising lack of scholarship on the impact of service-learning on the community, particularly from the perspective of the partnered community [21]. Studies that focused on the concerns of the university suggest best practices from the institution's perspective [22]. Several studies discuss the need for collaboration between universities and their community partners [23]. Research mainly emphasises the community partner organisation's perspective or evaluates how community engagement affects students [24]. The research often focuses on the relationship between the community partner and the university instead of the actual service-learning impact. Consequently, few studies have precisely measured service-learning projects' impact on communities [25].

The literature suggests that more focus should be placed on the community's involvement in service-learning projects, including local knowledge, to provide for the community's unique needs [26]. Furthermore, it is recommended that research be conducted on the actual impact of service-learning projects on the community instead of the impact of service-learning on the students or the university itself [1].

2.2. Information Technology Service-Learning Project

Since the aim of this research study was to actively involve community members in evaluating the most recent ITSL project, it is essential to understand the nature of this project. The ITSL project, aimed at enhancing computer literacy skills among rural community members, was executed through a meticulously planned process that involved various stakeholders and logistical considerations.

During the most recent project iteration, a total of 125 community members were recruited for the ITSL project by two community partner organisations, Mangaung Concerned Residents and the South African Red Cross Society (SARCS). A WhatsApp group was created to facilitate communication and coordination, providing participants with essential project details such as start dates, locations, and transport arrangements. The weekly training sessions were held in a well-equipped computer laboratory on the campus of the UFS, ensuring access to necessary resources for both learning and practical exercises. Additionally, transport between the campus and central community locations was provided free of charge, thanks to a financial contribution from the UFS CSI department and a sponsorship from the SARCS.

Nine second-year students enrolled in the CSIS2642 module took on the role of presenters for the ITSL project. As a prerequisite, all presenters had to be computer literate. While these students received limited presentation and public speaking training, they were tasked with delivering comprehensive computer literacy training covering MS Word and MS Excel over ten weeks. Each student presenter prepared and delivered sessions on assigned sections of the training content (developed by the course lecturer), conducted in English to ensure clarity and understanding among participants. Participants were also provided with hard-copy instructional materials to aid their learning process. Upon completion of the ITSL project, a graduation ceremony was

organised on the UFS campus to celebrate the achievements of the participants. During this event, participants received certificates for completing the MS Word and MS Excel training.

3. Research Method

In this research study, a non-experimental descriptive design was employed with a survey as the mode of inquiry [27].

3.1. Population and Sampling Decisions

The research population comprised the 125 community members who participated in the most recent iteration of the ITSL project. Purposive sampling was used since only community members who took part in the project were invited to participate [28]. Convenience sampling was also employed since an open invitation to participate was sent out via the same WhatsApp group used during the project. Consequently, the sample included community members who had completed the ITSL project and were willing (and able) to participate in the research activity.

3.2. Data-collection Method

An online self-completion questionnaire was deemed most appropriate for collecting quantitative and qualitative data. Since this study aimed to evaluate individual feedback, the questionnaire was cross-sectional, thereby providing a snapshot of what was happening within the designated group at that particular time [27, 29]. The questionnaire was divided into two sections. Section A (comprising 25 questions) was aimed at gathering information regarding the participants' perceptions of the ITSL project, while Section B focused on gathering biographical data such as gender, age, and home language.

For the closed-ended questions, three different question types (Yes/No, multiple choice, and rating) were used to elicit responses from the participants. Closed-ended questions using a five-point Likert scale allowed the participants to indicate a positive or negative experience, including how strongly they felt about their choice [30]. Open-ended questions provided opportunities for a more in-depth understanding of the participants' responses to specific closed-ended questions [27]. Google Forms was used to create an online version of the questionnaire for easy distribution to the participants. Before administering the questionnaire, a draft was piloted. The pilot study was used to assess and revise the phrasing and content of the questionnaire [27, 29].

An invitation and link to the online questionnaire were distributed via the WhatsApp group used for communication during the ITSL project. The participants were given two weeks to complete the questionnaire in their own time. Since all closed-ended questions were marked as required, the questionnaire could only be submitted if the participant had answered all of these questions. A total of 51 participants completed the questionnaire. These participants made up the eventual sample (N=51).

3.3. Data Analysis

All the data collected through the questionnaire were exported from Google Forms and captured in an MS Excel spreadsheet. Before the analysis, the gathered data were prepared, and the final dataset included data from all 51 participants (P1 to P51) who

had completed the questionnaire. Data analysis was conducted separately for closed-ended and open-ended questions. The responses from the closed-ended questions were exported to the Statistical Package for the Social Sciences (SPSS) Statistics for Windows, version 29.0, for statistical analysis after being numerically coded using MS Excel. Descriptive statistics were used to describe the data collected from the closed-ended questions in summary frequencies and averages [27, 29]. The means of the responses to the five-point Likert-scale items are reported using the weighted mean intervals suggested by Pimentel [30]. No inferential statistics were used since there was no need to generalise to a larger population [31]. The responses from the open-ended questions were collected and imported into NVivo for MS Windows, version 12.0, for analysis. Thematic analysis was utilised for open-ended questions since it was deemed suitable for analysing the participants' opinions and experiences [32]. Thematic analysis was performed according to the six steps developed by Braun and Clarke [33].

4. Results

The discussion of results is organised into four sub-sections. An overview of the participants' demographic data is followed by discussions of the three main feedback categories: Satisfaction with the ITSL project, its effectiveness, and participants' recommendations for future implementations.

4.1. Demographic Data

Of the 51 participants, 16 (31.4%) were male and 35 (68.6%) were female. Their ages ranged from 18 to over 50. The largest proportion of participants (37.3%) were between 25 and 29 years old, while only 3.9% were older than 50. The majority (58.8%) indicated Sesotho as their home language, with Setswana (33.3%) representing the second-largest language group. Overall, the participants indicated that their home languages represented five of South Africa's 11 official languages.

4.2. Satisfaction with the ITSL Project

The discussion in this sub-section focuses on the participants' reported satisfaction with various aspects of the ITSL project. The majority of the participants (64.7%) indicated that they believed the project was excellent, with 25.5% indicating that it was very good and 9.8% indicating that the project was good. The calculated mean for Question 1 was 4.5, which indicates that most participants experienced the ITSL project as excellent since the mean falls within the 4.20 to 5.00 interval suggested by Pimentel [30]. The participants' overall satisfaction with the project was also evident from their open-ended responses to Question 23. P3 mentioned: "*It is perfect for me at the moment*". Notably, none of the participants selected the "Fair" or "Poor" response options for Question 1.

To gauge the perceived success of the project in meeting participants' computer literacy needs, they were asked to rate their satisfaction on a scale of 1 to 10. An overwhelming majority (74.5%) selected the highest rating of 10. This sentiment is echoed in participants' feedback, such as P37's remark: "*I could help at work with the computer, and I felt more experienced than before*".

Despite the project's perceived success, some participants suggested including additional computer literacy content in future iterations. For instance, P42 expressed a desire for more advanced skills training: "*I would like the programme to include the next level of computer skills*". Moreover, it was noted that beginners may have been overwhelmed by the information provided, while some also requested more time for beginners to learn. These comments underscore the importance of reviewing project content and duration through collaborative discussion among stakeholders.

Participants overwhelmingly expressed their likelihood to recommend the ITSL project to others, with 72.5% indicating a high recommendation. The response from P3 validates this positive feedback: "*Many other people really do need the skills to improve their lives*". However, some participants noted accessibility challenges, particularly for those with employment commitments. One participant suggested alternative training days to accommodate employed individuals, highlighting the need for stakeholder discussion on scheduling to ensure inclusivity.

Most participants (56.9%) rated presenter preparedness as excellent, with 29.4% very good and 13.7% good, resulting in a mean score of 4.4, indicating high satisfaction. Similarly, most participants (51%) rated presenter communication skills as excellent, with 29.4% very good and 19.6% good, yielding a mean score of 4.3, falling within the excellence range suggested by Pimentel [30].

While overall feedback on communication skills was positive, some participants advocated for improvement, particularly considering that English was not the home language for many presenters or participants (who spoke five of the 11 official South African languages). This underscores the need to address language barriers to ensure equitable understanding. Although no specific proposals were made for improving communication skills, these responses underscore the importance of collaborative discussion on this matter.

Most participants (45.1%) indicated that they felt the duration of the training was excellent, with 41.2% rating it as very good, 11.8% as good, and 2% as fair. The mean for Question 11 was 4.3 (Excellent). The feedback from the participants to the open-ended questions also confirmed that most of them reacted positively. However, some participants requested extended time for learning, as seen in the following statement by P37 (Question 22): "*I wish that the course could get extended although it is a short course. I feel like I could have learned more in a longer period*". These results require investigating the project duration and content covered to consider all stakeholders' distinct needs and expectations.

The majority of participants (52.9%) rated the venue and equipment as excellent, with 37.3% rating it very good and 9.8% good, resulting in a mean score of 4.4 (Excellent). This positive feedback is unsurprising, given that the venue was a fully functional computer laboratory at the university where the project was conducted.

While most participants expressed satisfaction with the venue and equipment, some highlighted the need for improved campus access and venue access. For instance, participant P34 suggested: "*I would like them to make it easier for us to enter and exit the campus and venue*". These responses indicate that despite overall satisfaction, participants encountered difficulties accessing the UFS campus and project venue. Addressing this issue requires collaboration among all project stakeholders to ensure inclusivity for all participants.

Most participants (56.9%) rated the “graduation” ceremony as excellent, with 31.4% rating it as very good, 9.8% as good, and 2% as fair. The mean was 4.4, indicating a high level of satisfaction with the ceremony. Participants particularly appreciated receiving certificates upon project completion. However, some expressed dissatisfaction with the catering, as P2 noted: “*The food after the certificate ceremony can be better*”. Notably, participants were not consulted regarding food preferences beforehand, highlighting the need for inclusive decision-making processes for future ceremonies, considering cultural differences among participants.

Most participants (47.1%) rated the instructional materials they received as excellent, with 33.3% rating them as very good and 19.6% as good. This finding is confirmed by a calculated mean of 4.3 (Excellent). No specific complaints or recommendations were received regarding the instructional materials used during the project. Nonetheless, there is a need to rethink the content provided during the project with shared input from all stakeholders.

4.3. Effectiveness of the ITSL Project

The discussion in this sub-section focuses on results in relation to the participants’ perceived effectiveness of the project in improving their computer literacy as well as increasing their computer usage and chances of finding employment.

Computer literacy entails understanding how to use computers and application software for practical purposes [34]. Most participants (62.7%) indicated that they had never used a computer before the ITSL project, with only 37.3% indicating that they had some previous computer-use experience. Considering the definition of computer literacy and the responses from the participants, it can be assumed that most participants in the project were not computer literate at the start of the project. With computer literacy emerging as a requirement in basically every career, from a nice-to-have skill to a job-critical skill [35], it can be assumed that being computer illiterate harms the employability of these individuals.

Surprisingly, despite a high proportion of first-time computer users, 64.7% of participants reported feeling confident using a computer, while 35.3% did not. Further examinations showed that among those who had used a computer before, confidence was prevalent at the project’s outset, with 18 out of 19 participants expressing confidence. Conversely, among those who had never used a computer, 15 felt confident, while 17 did not. This indicates a notable shift in confidence levels, particularly among participants with no prior computer experience. The fact that 15 participants reported confidence despite lacking prior computer use is noteworthy. This confidence might stem from digital literacy, defined as proficiency in using digital platforms [34]. Given participants’ engagement in a WhatsApp group during the project, it’s reasonable to infer smartphone proficiency. Notably, when asked if they felt more confident post-project, all participants responded affirmatively. These findings suggest that most participants regarded themselves as computer literate after attending the project.

Most participants (76.5%) reported using computers post-project, indicating sustained engagement with acquired skills. Only 23.5% reported no computer use since project completion. This is encouraging, suggesting that participants are actively applying their newfound skills, mitigating the risk of skill atrophy due to limited computer access.

Participants who used computers after completion of the project were asked about the tasks they performed, yielding four thematic responses. The participants indicated that they could productively use their newfound computer literacy skills to engage in new and existing employment by completing computer-related tasks that were previously impossible for them. Additionally, several participants indicated that they used a computer to design and distribute their curriculum vitae (CV) to apply for employment. Responses such as these suggest that the project empowered these individuals to use new avenues of seeking employment while using their newly acquired computer literacy skills. The participants also indicated that they used computers at home for self-use. These findings underscore the project's transformative impact, enabling participants to contribute to employment-seeking efforts, support family education, and continue personal learning endeavours.

Participants who had not used computers post-ITSL project cited two main reasons. Firstly, limited computer access at home or in public spaces hindered skill retention, underscoring ongoing digital disparities. Secondly, some participants' job roles did not require computer use, posing challenges in maintaining the acquired skills. As with many other skills, computer literacy skills must be constantly used and practised to retain and improve these skills [34].

The participants' employment status was assessed during the project and nine months later. Initially, 74.5% were unemployed, decreasing to 54.9% after the project — a 19.6% decrease. Part-time employment increased from 13.7% to 19.6%, and full-time employment from 11.8% to 25.5%. Participants attributed their employment gains to the project, citing experiences like, *"I've struggled to get a job, but after I completed and received my certificates, I got a job at the Department of Health as an admin clerk"* (P33) and *"I got an internship. It was about fixing computers, connecting and upgrading them"* (P4). These findings underscore the project's positive impact on employment prospects, suggesting potential community demand for expanded skills training in computer repair and upgrading (which falls outside this project's scope).

4.4. Recommendations for Future Implementations

The discussion in this sub-section focuses on the recommendations made by the participants regarding future ITSL projects.

In Question 22, the participants were asked which aspects they thought should stay the same for future projects. Their responses were thematically analysed, with four themes emerging. The first theme indicated that the participants believed the project's scope, more precisely the content and duration, should not change. A second theme indicated that many participants believed nothing in the project should change, which means that it is already successfully addressing their needs. Responses such as *"All of it should stay the same"* (P10) suggest a need for discussions to stimulate ideas and improvements for the project since the participants struggled to identify new ideas to improve the project individually. The third theme indicated that the participants believed that the project should remain free of charge. This response can be expected as many individuals are experiencing difficulties accessing employment opportunities and struggling with poverty. The fourth theme indicated that the participants believed that the ITSL project should still be presented at the UFS campus venue and use UFS equipment. They also indicated that service-learning students should continue to present the training.

The participants were asked to make specific recommendations for implementing the next project. Six themes emerged from the responses. The first theme showed that most participants indicated that they had no recommendations or that the project was already perfect. This lack of feedback regarding recommendations for improvement could suggest that the participants found it challenging to identify aspects that could be improved or changed. This could be due to most participants not having any prior post-school education. The ITSL project created the first opportunity for most participants to visit a university campus. The participants, therefore, might have found it challenging to identify improvement opportunities because they had not experienced similar training experiences before and thus had no other frame of reference for a comparison to the ITSL project. This problem could potentially be addressed through discussions between all project stakeholders in a group setting to elicit responses from the participants that they could not have identified on their own.

While most participants advocated for maintaining the project unchanged, participant P18 expressed a differing view, stating, “*None, let the project progress*”. This indicates that some participants acknowledge the necessity to adapt the project to evolving community needs and environments (Theme 2). The participants also indicated that they believed the project’s scope should change (Theme 3), specifically its training schedule (incorporating more training days during the week) and adding more content.

The fourth theme addressed recommendations for changes during the ITSL project, namely improving the presenters, making the campus more accessible to community members, and improving the transport provided. The participants also indicated that they believed the project should expand its recruitment to rural areas that are not currently included (Theme 5). It was also indicated that more could be done to ensure employment opportunities for the participants after completing the ITSL project (Theme 6).

Participants were also asked to provide feedback on other aspects of the project in an open-ended question. Thematic analysis revealed three main themes in their responses. In response, participants expressed interest in discussing further learning opportunities beyond the project’s scope, practical arrangements during the project (such as UFS campus welcoming and project ceremony catering), and the potential for creating employment opportunities for the youth. This was particularly pertinent given the high unemployment rate among participants, as emphasised by P10’s comment: “*The ITSL project is a once-in-a-lifetime opportunity for unemployed youth*”.

5. Discussion

Most of the ITSL project participants expressed high satisfaction with the program, indicating they would recommend it to others. Despite lacking specific community input in its planning, the project was well-received, with participants praising the presenters’ preparedness and instructional skills. Satisfaction extended to various aspects of the project, including venue, equipment, instructional materials, and the graduation ceremony. While there were some negative feedback and suggestions for improvement, the overall positive response may stem from the scarcity of similar opportunities in the community.

The project notably impacted first-time computer users, boosting their confidence and computer literacy. Many participants found employment after completing the project, attributing their success to the skills acquired and the accredited certificates received. However, some participants faced challenges accessing computers after the project due to limited availability or the nature of their job roles not requiring computer use.

Participants expressed a desire to maintain five aspects of the project for future iterations, specifically the course content, duration, cost, venue, and presenters. While some recommendations for changes were made, such as recruiting from rural areas and ensuring post-project employment opportunities, participants struggled to envision significant improvements. This could be due to their gratitude for the free training provided or a lack of reference points for comparison. Moving forward, fostering open discussion among stakeholders, including participants, is crucial for tailoring the project to better suit community needs.

6. Conclusions

This study aimed to evaluate participant perceptions of the ITSL project's impact, focusing on their satisfaction with the project, the project's effectiveness, and to identify areas for improvement in future implementations. Most participants believed the project successfully met their computer literacy needs and expressed strong recommendations for it. Despite the lack of specific community input in its development, participants held the project in high regard. The majority were first-time computer users at the project's outset, and a self-reported reduction in post-project unemployment suggests positive outcomes, with many attributing their employment success to the accredited certificates obtained.

Overall, these findings affirm the ITSL project's potential to narrow the digital divide in the community. However, participants identified areas for improvement, including presenter quality, recruitment strategies, project duration, campus access, and additional learning opportunities. Furthermore, the study revealed significant shortcomings in the project's implementation, such as a lack of community engagement, consideration of community needs, and language preferences. Additionally, power imbalances and limited rural community access were noted. Improving the ITSL project will require inclusive dialogue among stakeholders to address identified issues and devise community-informed strategies. Facilitating discussions where all parties contribute equally is vital for enhancing the project's impact and fostering a reciprocal university-community partnership. This will be essential for enhanced community engagement and consideration of community needs to move this project from a community-focused to a community-driven service-learning project.

Many participants in the ITSL project were first-time computer users and faced barriers to accessing educational resources prior to their involvement. This demographic represents a particularly valuable perspective, as their fresh insights and perspectives can enrich discussions about project improvement and future directions. To involve participants in generating ideas and solutions for the project's future, the following two approaches are deemed viable:

- Community Workshops: Organising community workshops specifically tailored to gather input from community members and project stakeholders could provide a platform for participants to share their experiences, challenges, and ideas in a supportive environment.
- Focus Groups: Conducting focus group discussions with participants to delve deeper into their perspectives on the project and potential areas for improvement could elicit valuable insights and spark creativity.

7. Limitations

The study's findings are based on a specific context: the Information Technology Service-Learning (ITSL) project facilitated by the University of the Free State in South Africa. The results may not be generalisable to other service-learning projects or communities with different socio-economic backgrounds, educational levels, or cultural contexts.

8. Future Research

Community workshops and focus groups could assist in creating a supportive and empowering environment that encourages active participation and collaboration. By involving former and future project participants, community partner organisations, service-learning students and university stakeholders, these approaches should be well-suited for gathering ideas and solutions for the project's future. By establishing this direct line of communication between the university and the community, future research projects could assist in fostering a sense of ownership and collaboration, with the ultimate goal of transforming the ITSL project into a community-driven service-learning project that truly reflects the needs and aspirations of those it seeks to serve.

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Investigating Automatic Grading of SQL Queries using String Similarity Measures

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Abstract. Manual grading of SQL queries in higher education institutions poses challenges especially in cases involving multiple assessors and for large classes. The challenges include the tediousness of the task as well as inconsistencies in awarding marks. This, together with advancements towards technology-based assessments, necessitates the need for automatic query grading systems. Most of the automatic query grading methods in literature focus on determining whether an SQL query matches the solution or not, and not the extent to which they match such that a partial mark is awarded. This paper therefore presents an investigation into the use of string similarity measures as an initial investigation into minimal capabilities of widely applied existing similarity methods. This will hopefully provide insight into issues that must be considered when designing automatic query grading systems. String similarity measures are commonly used in Information Retrieval systems. The major difference between regular strings and SQL queries is that SQL queries have a defined structure and must have the correct syntax. String similarity measures can therefore be used only as baseline systems in further experiments, with some working better than others. The results of the investigation into the use of string similarity measures to grade queries brought up several issues that must be considered while grading queries. These include the subjectivity in query grading methods especially how to grade correctness or otherwise of syntax, the approach in allocating marks to various sections of the query and how missing parts and unnecessary additions in the solution affect grading.

Keywords: Automatic SQL Grading, String Similarity, Assessment

1. Introduction

Manual evaluation of students' hand-written Structured Query Language (SQL) queries has always posed challenges in academic setups. The process of checking a student's solution and comparing it with a model answer is both error-prone, tedious [1] and time-consuming [18]. The task requires the evaluator to assume the task of a Database Management System (DBMS) to evaluate whether the steps specified can execute correctly and give the required results. While having the advantage of the evaluator easily spotting mistakes and highlighting them in the solution for the benefit of the learner, the eventual result the evaluator is interested in, especially in examination settings, is the assigning of a mark to the answer presented, out of a given total mark based on its correctness, which is essentially a similarity score. Hence the problem can

be solved through the development of systems that calculate the similarity score automatically. One major advantage of such a system will be consistency in the allocation of marks, which has major benefits for the grader, especially in grading queries for large classes. Automatic SQL query grading systems that have been implemented in literature utilise methods either involving the use of query results, or similarity methods such as edit distance, structure-based similarity with feature presentation, machine learning techniques and vector similarity metrics. SQL query similarity has also been applied in many other applications such as clustering in access plan selection and reuse [2, 3] for query optimization, extracting patterns from query logs for easier understanding [4] and clustering in query logs to discover user interests [5].

Automatic SQL query grading systems that have been previously implemented either use query results to determine if the solution is correct, for example in [6] and [7] or apply query similarity solutions which do not involve query execution, for example in [4]. Automatic SQL query similarity solutions proposed in the literature include using edit distance [1], structure-based similarity using heuristics with feature representation [4], similarity based on access area (the part of a database accessed during the execution of a query) [9], using machine learning techniques such as SVM models in [10] and [11] and vector similarity metrics with queries represented as collections of abstract features [12].

Solutions therefore cut across different IR models (for example edit distance and vector similarity), Machine Learning (SVM models) and heuristic methods. The methods rely on different techniques for defining the features of SQL queries used in determining similarity. Current automatic systems focus on determining whether an answer is correct or wrong, rather than determining to what extent the solution matches a given answer, therefore awarding partial marks [1]. Developing a system to award partial marks is still challenging to do in a consistent, equitable and meaningful way [18].

The aim of this research is to therefore explore the results of employing string similarity measures to the process of evaluating students' queries and to summarise the issues encountered thereof as a step towards developing automatic SQL query grading systems. The process involves SQL component extraction and pattern matching, coupled with similarity measures, to grade students' query solutions against given sample solutions automatically. The approach does not only take into consideration the commonality of features between the students' solutions and the model answers, but also considers sequential dependence between the components making up the SQL statement. This is because in SQL queries the order of the components is significant, as SQL queries must conform to a specified structure. Hence query grading essentially begins as a pattern-matching process between components in a student's solution and those of the model answer. In a case where there are several model answers, the process proceeds with the solution(s) with the matching pattern. Once a pattern is found, the process then focuses on 'understanding' and matching the contents of the arguments from both the student's query and the model solution. This process incorporates a scoring technique based on the degree of match between the components of the student's query to the closest model answer.

For the similarity score, we employ some common string similarity measures used in Information Retrieval (IR) systems. The Longest Common Subsequence Ratio

(LCSR) [13], Cosine Similarity [14], and Jaccard similarity [15] are used in this regard. The process concludes by evaluating these scores against the manually allocated scores by the lecturer and summarising the observations.

The remainder of this paper is organized as follows. Section 2 presents the research problem and objectives. Section 3 discusses related work, focusing on the structure of SQL queries and the various similarity algorithms used. This includes text similarity scores which will be utilized as baseline similarity scores in this research. Hence selected IR methods – the LCSR, cosine similarity, and Jaccard similarity are reviewed. Section 4 presents the dataset, the evaluation approach that will be used, and the approach of evaluating SQL queries based on the selected IR methods. Section 5 presents the results of the experiment and their discussion. Section 6 concludes the paper by summarizing the contribution of this research.

2. Research Problem and Objectives

This research investigates automatic SQL query grading to counteract problems encountered in grading queries manually. Compared to regular string comparison, SQL query grading is more complex since SQL queries, unlike other regular strings, have a defined format, must conform to a given syntax, and there may be more than one solution to a single query [18]. With only the schema and no database instance available, automatic SQL query grading systems depend only on matching the students' solutions to one or more model solutions from the lecturer. Combined with the fact that the same query sub-components may be ordered or written in different ways in the same solution, the process of query grading becomes more complex and requires the matching of individual components in addition to the predefined structure.

The objective of the research is to therefore conduct an experimental analysis of string similarity as the baseline for comparison with SQL query similarity methods and to report issues discovered in the process. The scores are evaluated against scores manually allocated by the lecturer.

3. Literature Review

3.1. The Structure of SQL Queries

SQL is a data sublanguage that allows access to relational databases that are managed by relational database management systems (RDBMS) [16]. SQL has many dialects, causing a variation in syntax. These, however, are minor [17, 18]. To do automatic grading, it is important that the SQL queries should have one style and syntax [6]. The American National Standards Institute (ANSI) has defined a standard for SQL, which has been accepted by the International Organization for Standardization (ISO) and was published in 1987 [19] which has been reviewed over the years to keep up with the trends in the database world. Most books and publications adopt this standard.

The most common statements used in students' assessment are usually Data Definition Language (DDL) and Data Manipulation Language (DML) statements, with SELECT queries being the most used as it is the core SQL [20]. The SELECT statement is structured as follows:


```

SELECT [* | DISTINCT] <column list>
FROM <table list>
[WHERE <condition list>]
[GROUP BY <column list>]
[HAVING <condition list>]
[ORDER BY <column list> [ASC | DESC]]

```

Where **SELECT** specifies the attributes to be returned by the query(**DISTINCT** removes duplicates); **FROM** specifies the tables from which the data will be retrieved, **WHERE** filters the rows of data based on specified criteria; **GROUP BY** groups the rows of data based on shared values of attribute(s); **HAVING** filters the groups formed in the **GROUP BY** clause based on specified criteria while **ORDER BY** sorts the final query result rows in ascending(**ASC**) or descending(**DESC**) order based on the values of one or more attributes[18].

This syntax is adopted in this paper and the vendor variants and extensions are not considered in this research since they are rarely used when writing queries manually. Further work, however, might need to consider the different variations for the solution to be more universal.

3.2. SQL Queries and Similarity

Similarity can be approached by representing objects as collections of features, and similarity between them is expressed as a linear combination of the measures of their common and distinctive features [21]. Similarity has also been defined as the ability to balance commonalities and differences between objects, resulting in a similarity judgement [22]. Jimenez and Gelbukh [22] also explained that while people and most animals have this intrinsic capacity, it poses a challenge for computer systems to generate similarity. This is because while the exact comparison of any two objects is straightforward approximate comparison, on the other hand, is complicated as it must take into consideration issues such as noise, nuance, and ambiguity.

Computing similarity between two queries may involve either using only the query structure [4], based on the assumption that queries that are similar in structure are issued to perform the same duties (conceptual similarity), or it could be based on both queries computing the same results (logical equivalence). Conceptual similarity requires that the query be divided into parts of fragments that can serve as features for comparison, while logical equivalence assumes that one has access to the data in the database such that the results can be computed.

Both these methods have their disadvantages. Conceptual similarity might depict high similarity for queries that get completely different sets of data, for example, where the only difference is the tables specified in the FROM Clause. Due to the declarative nature of SQL queries, syntactically distinct queries may still be semantically equivalent [4]. Similarly, two queries might be semantically similar but retrieve different results due to some filtering conditions [23]. For example, Query A and Query B below are syntactically distinct but semantically similar since they compute the same results, while query C is conceptually similar to both query A and Query B but logically distinct from both [4].

Query A:

```
SELECT name FROM user WHERE rank IN ('adm', 'sup')
```

Query B:

```
SELECT name FROM user WHERE rank = 'adm' UNION  
SELECT name FROM user WHERE rank = 'sup'
```

Query C:

```
SELECT SUM(accounts.balance) FROM accounts NATURAL JOIN  
user WHERE user.rank = 'adm'
```

Computing SQL queries similarity has been found to be NP-complete for earlier versions of SQL and Turing-complete for later versions which use recursive queries [4]. The similarity methods must consider the fact that there can be many variations for the same SQL statement [7], which makes the process difficult.

The first step in query similarity is to find an appropriate method for query representation before determining a query similarity method to use [2]. Several attempts have been made towards detecting SQL query similarity in grading queries. Three examples of these are discussed below.

Singporn et al. [6] graded queries using weighted equivalence edit distance metric. Using a variety of query canonicalization techniques, irrelevant syntactic and semantic differences were removed from the student and instructor queries and the edit distance computed between them. Canonicalisation, whereby a set of rules were applied to the queries, is used before the queries are represented as ‘flattened’ tree structures. Edit distance is then calculated based on the cost needed to insert, remove, replace, or move a node/subtree from one position of the flattened tree to another.

The SQL-LTM tool [24] aimed to evaluate correctness of students’ queries and detect semantic errors on otherwise syntactically correct SQL statements. This was achieved by generating an intermediate XML representation of the student query, analysing it, then comparing it to the representation of the instructor’s reference solution. The analysis involves mapping the structure of the query in terms of the query and its sub-query blocks and their relationships and applying transformation patterns using LINQ (Language-Integrated Query) to SQL to bring the student query to a form that is structurally similar with the instructor’s solution. If the student’s query is wrong, feedback is provided with relevant information to allow the student to fix their query.

Deep learning with a bidirectional encoder representation from transformers (BERT) model was applied to understand the syntax and semantics of SQL statements in [18]. By training the model on a dataset of SQL queries and their corresponding grades, a model that could automatically grade new questions accurately was created. The evaluation of the model showed better performance than a baseline model which utilized a convolutional neural network. A 92-93% accuracy rate was recorded. The model’s performance, however, was limited due to lack of training data. Other challenges encountered were related to the structure of the query and the processing of structured text and concepts related to databases. The authors concluded that more training data across a wider range of submissions and assignments could improve the model’s performance and generalization capabilities.

3.3. IR String Matching Models

Introduction. Natural language processing systems usually employ some text similarity measure, often character-based, using different techniques. Jimenez and Gelbukh [22] classify text similarity functions according to the information used to calculate their similarity scores. Popular techniques include Edit Distance and the length-normalized measure, the Longest Common Subsequence Ratio (LCSR). The advantage of these two measures is that they do not require training data [8].

Static similarity functions like Edit Distance use information contained in the surface of the pair of texts that are being compared. *Adaptive similarity functions* build up on this by using the entire collection of text being compared, often recombining text collection information to produce a similarity score. An example is the cosine tf-idf function. Lastly, *semantic similarity functions* use additional resources based on large corpora, knowledge, or combinations of these to compute similarity between two texts. Examples include the use of POS-taggers and the use of semantic networks like Wordnet and Ontologies. Jimenez and Gelbukh[22] further state that each of the similarity categories above could use the previous category as a baseline.

The Longest Common Subsequence Ratio (LCSR). Dan Melamed [13] proposed the Longest Common Subsequence Ratio (LCSR) to compute the match between two tokens A and B as the ratio of the length of their longest (not necessarily contiguous) common subsequence (LCS) and the length of the longer token.

$$\text{LCSR}(A, B) = \frac{\text{length}[LCS(A,B)]}{\max[\text{length}(A), \text{length}(B)]} \quad (1)$$

This method is one of the most common measures of string similarity. It considers the number of matched and mismatched characters as well as their sequential dependence.

The Jaccard Index. The Jaccard similarity index [15] measures the relative size of the overlap of two finite sets A and B. It is defined as

$$J(A, B) = \text{def} \frac{A \cap B}{A \cup B} \quad (2)$$

The associated Jaccard distance will then be:

$$1 - J(A, B) = 1 - \frac{A \cap B}{A \cup B} \quad (3)$$

To measure the Jaccard distance for two strings each string should be divided into sets of tokens or n-grams. The Jaccard distance measures how dissimilar two sets are, hence the lower the distance, the more similar the two strings.

Cosine Similarity. Cosine similarity measures the similarity between two vectors of an inner document space by measuring the cosine of the angle between two vectors to determine whether they are pointing in the same direction [14]. In document similarity documents are represented by term-frequency vectors, which record the frequency of a particular word or phrase in the document. To focus on the words that both documents have in common and the occurrence frequency of such words and disregard the dissimilarity of documents, non-matching words are ignored.

If x and y are two vectors to be compared

$$\text{Sim}(x, y) = \frac{x \cdot y}{\|x\| \|y\|} \quad (4)$$

Where $\|x\|$ is the Euclidean norm of vector $x = (x_1, x_2, x_3, \dots, x_n)$ defined as $\sqrt{x_1^2 + x_2^2 + \dots + x_n^2}$.

Similarity value of 0 means that the vectors are at 90 degrees to each other, meaning that they do not match. If the value is 1 it is a complete match, hence the closer the value is to 1, the greater the match between the two vectors.

Summary. SQL queries have a defined structure. The SELECT statement is the most used SQL statement and contains clauses that must appear in a specified order. SQL query similarity can be based on the structure of the queries (conceptual similarity) or based on the two queries computing the same results (logical equivalence). Both these methods have their own disadvantages. An appropriate method for query representation precedes computation of similarity. These include tree structures, XML representations and other features. In comparison, Natural Language Processing systems utilize either surface information contained in the texts being compared, information on the whole corpus or additionally use external resources to determine similarity between two pieces of text. Given that SQL Queries are essentially text, text similarity measures can be used as baseline systems in computation of SQL query similarity studies.

The next section describes an approach to compute a similarity score between SQL queries (students' solutions and the lecturer's model solution(s)). Three common text similarity measures discussed above are utilized for calculating similarity scores, which will ultimately be compared with the manual scores given by some lecturer.

4. Research Methodology

4.1. Dataset

To grade queries, one requires model solutions to match the students' queries against. The experiment assumes that all the possible variants of the query have been provided. The experiment also utilizes 100 student queries that are extracted from marked examination scripts for the 2nd year database course in the University of Botswana. The queries are answers to 3 questions (example question and solutions below) with each question having 30-35 student queries.

Question:

Consider the following relational schema:

STUDENT (stud-id, stud-name, age, address)

COURSE (c-code, c-name)

TAKING (stud-id, c-code, grade)

Write the query below in SQL:

Get the names of students who are doing a course called CSI471 AND a course called CSI481.

Solution 1:

```
SELECT stud-name FROM STUDENT, TAKING WHERE STUDENT.stud-  
id = TAKING.stud-id AND (TAKING.c-code = 'CSI481' OR  
TAKING.c-code = 'CSI471')
```

Solution 2:

```
SELECT stud-name FROM STUDENT, TAKING WHERE STUDENT.stud-  
id = TAKING.stud-id AND TAKING.c-code IN ('CSI471',  
'CSI481')
```

Solution 3:

```
(SELECT stud-name FROM STUDENT, TAKING WHERE  
STUDENT.stud-id = TAKING.stud-id AND TAKING.c-code =  
'CSI471') UNION (SELECT stud-name FROM STUDENT, TAKING  
WHERE STUDENT.stud-id = TAKING.stud-id AND TAKING.c-code  
= 'CSI481')
```

The students' queries are handwritten; hence they are captured into a text file to prepare them for the experiment, which requires them to be in electronic form. The lecturer's model solution is also in electronic form. The method only utilizes the query structure.

4.2. Assumptions

This research employs a method of parsing SQL queries and comparing the tokens using text similarity measures. The main aim is to determine the extent of similarity between the lecturer's solution(s) (A) and the student's answer (B). The approach makes a few assumptions:

1. The method only utilises the query structure. No data or query results have been provided from the database.
2. The query has not been pre-processed to correct, for example, punctuation, spelling mistakes etc. Pre-processing can possibly affect the degree of similarity between the A and B, hence invalidating or affecting the goal of the research, which is to evaluate the answer the student provides, hence checking their understanding. The only pre-processing that can be done is to remove punctuation or characters not affecting the syntax of the query such as brackets and the semicolon showing the end of the query.
3. The examiner's marks that will be used to evaluate the method used are from only one examiner.
4. The research is limited to SQL SELECT queries only.

4.3. Evaluation of Results

To measure the success of IR systems in serving users and helping fulfil their information needs the systems are evaluated. The Cranfield approach [25] is a method of evaluation commonly applied to IR systems which is based on a test collection made up of a document collection, topics/queries and a relevance assessment. The idea is to use different retrieval systems to produce a ranked list of documents for each query and then compute each system's effectiveness for every query in the test collection as a function of relevant documents retrieved. In addition, systems often use statistical tests to determine whether the differences between the effectiveness scores of systems and their rankings are significant.

The evaluation method described above can be adopted, with modifications, for use in the approach used in this research. In this case, the system is ascertaining the extent of the relevance of each student's solution to the nearest model solution. Hence the model solution(s) act as the test collection, students' solutions as the queries and the mark given by the examiner serves as the relevance judgement. The adaptation, however, must take into consideration that the setup in this research is different, with different interpretations for the document collection, queries, and relevance assessment, and thus the experiment cannot follow the same methodology used in similar IR studies. While the technique used will provide a 'ranked list' in the case of more than one model solution, the goal and interest are only in the model solution closest to the student's query in terms of similarity score. The closeness of the nearest model solution to the examiner's mark will therefore serve as the basis of the evaluation. Thus, the evaluation measures how far off the mark (examiner-allocated mark) is from the mark as calculated by the nearest algorithm. Therefore, the average difference between the results of the grading method and the examiner's mark serves as the basis of the evaluation method.

4.4. Research Approach

Baselines are used in the IR field when testing new retrieval techniques to show improvement in results. The value of a novel technique is demonstrated by measuring statistically significant improvements over one or more baselines [26]. To demonstrate confidence that the new technique is a contribution to the field, it should be compared against a strong baseline. It is imperative, therefore, that the baseline is nothing less than the state of the art [26].

The objective of the study is to come up with a strong baseline for measuring SQL query similarity, which can be used to evaluate future similarity measures. This process must take into consideration that the technique used should consider similarity between the queries, as well as the difference, or dissimilarity between them. Another important aspect in queries is that the terms should be in a certain order, or sequence, hence the need for the technique to embrace sequential dependence. Bearing this in mind, the three measures below were selected and tested with the goal of using the results as the baseline for further experiments in similar research. Below is a discussion featuring the selected similarity measures and the reason for their selection.

Cosine similarity. Cosine similarity is based on frequency of common terms in the two strings (documents) being considered, giving a higher weighting to rare terms and a lower weight for terms that are frequent. It does not take into consideration the order of the terms in the two strings. This measure is therefore considered basic in this research as it only calculates basic similarity of strings.

The Jaccard Index. The Jaccard Index measures the relative size of the overlap between two strings by taking into consideration the number of tokens that are common amongst them as well as the total number of tokens in both strings. It therefore considers the diversity of the two strings, hence their dissimilarity. It is one of the superior static similarity functions as it goes beyond just the commonality of the tokens in the strings, but also considers tokens that are outside the intersection. However, the order of the tokens in the strings is ignored. This measure is considered better than cosine similarity since it goes beyond similarity and includes a measure of dissimilarity.

The Longest Common Subsequence Ratio (LCSR). In SQL the order of the clauses is important. The Longest Common Subsequence Ratio (LCSR) presumably goes a step further than cosine similarity and Jaccard similarity by considering the sequential dependence of the tokens and mismatches between the strings in addition to the commonality of the tokens. However, this only works well for the query clauses and not the arguments inside the clauses. If there are multiple components inside the clause and they are not aligned in the same order in the two queries, this function is expected to perform poorly.

To compare students' queries to the model solution(s), the approach starts with parsing both queries into tokens based on the components in both the student's and the lecturer's queries. A Python Parser, `sqlparse`¹, is adopted and used to get the components of the queries. For example, the query

```
select stud-name, stud-id, c-code from student, taking
where taking.c-code='csi471' or taking.c-code = 'csi481'
is parsed to give the following tokens:
```

```
[SELECT]
[stud-name,] [stud-id,] [c-code]
[FROM]
[student,] [taking]
[WHERE]
[taking.c-code='csi471'] [or] [taking.c-code = 'csi481'].
```

The structure of the query is also determined. For example, for the query above the structure is 'SELECTFROMWHERE'. Other possible structures are 'SELECTFROMWHEREunionSELECTFROMWHERE' and 'SELECTFROMjoinWHERE', for example. The tokenization and determination of structure are done for both the student's solution and all lecturer's solution(s). This then enables selection of the appropriate model solution to use for similarity based on the closest query structure of the student's solution to the lecturer's solution. The similarity match then proceeds by invoking each of the similarity measures described above in turn using formulas (1), (3) and (4). The results are then compared with previously allocated manual marks from examination scripts.

5. Results and Discussion

The three similarity measures presented above were used to compare the student's query and the model solution(s). The aim was to assess how the similarity measures perform compared to the actual mark allocated by an examiner. The initial hypothesis was that the three similarity measures would progressively perform better in the order of Cosine similarity, followed by the Jaccard Index with the LCSR being the best.

The results for each set of queries from the 3 questions show similar results. Fig. 1 shows a sample of the results over 1 question with 30 student's solutions. It shows the resulting scores from the 3 similarity measures compared to the manual mark. The results are ordered in terms of the manually awarded mark, from smallest to largest. The Jaccard Distance clearly consistently shows high scores from wrong to correct queries, while Cosine Similarity and the LCSR show increasing scores from wrong to correct queries.

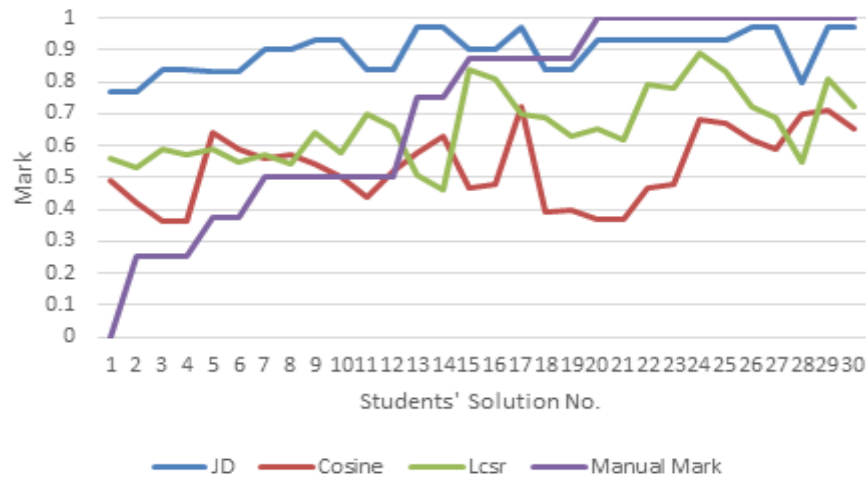


Fig. 1. Scores for 30 queries compared to the manually allocated mark.

The results for 100 queries, as shown in Table 1 and Fig. 2 below. Fig. 2 shows the resulting scores from the 3 similarity measures compared to the manual mark while Table 2 presents an analysis of the same data using different aggregate measures.

Table 1. SQL grading scores in comparison with manual grades

	Similarity Measure		
	Cosine Similarity	Jaccard Index	LCSR
Average Distance from Mark	0.28	0.62	0.22
Std Deviation (using mean of best predictions)	0.20	0.04	0.25
Percentage share of best prediction	30%	13%	57%

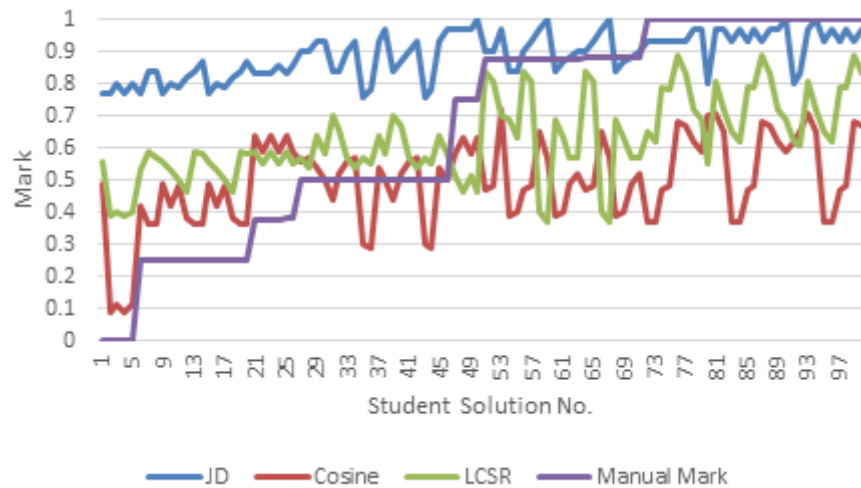


Fig. 2. Scores for 100 queries compared to the manually allocated mark.

The results of the 3 similarity measures, however, show mixed results. The average distance from the mark and the percentage share of best prediction both point towards the LCSR as the best, with Cosine Similarity being the second and outperforming the Jaccard Index in both. However, the Jaccard Index, when it is the best, shows the smallest mean margin of distance from the actual mark as shown by the standard deviation of predictions when it is best. It is also worth noting that the LCSR performed very well for higher scores/marks followed by Cosine Similarity, while the Jaccard Index seemed to be constant in its prediction. The Jaccard Index examines the occurrence of terms that are similar as compared to those that are not. Hence it indicates that the two queries are similar in terms of the terms contained in them. This might be attributed to the fact that the student's solution and the lecturer's model answer have a high probability of using the same terms, and without considering syntax and order of terms, the two queries look very similar.

The results therefore point towards LCSR is a better measure for similarity because the order of the terms is of paramount importance in the queries, while the Jaccard Index is the best measure of dissimilarity since it only works best when the two queries contain very different terms. It is however worth noting that the average distance from mark in LCSR is still very high (22% from the actual mark). Cosine similarity, on the other hand, is better than the Jaccard Index because the focus is mainly in determining terms that are similar and ignoring the mismatches since it mainly focuses on text that is the same.

While the similarity measures above apply different methods to give a score for the extent of match between the lecturer's solution and the student's answer, it is worth investigating how different lecturers decide on the mark allocation, and partial marks thereof, for a given SQL query. While cosine similarity and the Jaccard Index focus on the terms in the query and 'weigh' them the same regardless of which part of the query

they appear in, the LCSR looks at the longest subsequence, not necessarily contiguous, and not in corresponding positions. Both are not ideal because individual terms on their own do not have much significance in the query. Rather the way they are combined, and their positioning are essential factors when evaluating queries.

Other considerations are to do with ‘weighing’ different parts of the query. For example, does specifying the wrong columns get the same penalty as specifying the wrong tables or the wrong conditions for filtering the data? If the query gets the wrong results because of a wrong condition statement, is it the same as the query that has the wrong tables and gets the wrong attributes with the right conditions? What is the penalty for wrong syntax and extra parts on the query? Other similarity measures also have different algorithms applied, which do not specifically suit query similarity. Therefore, it makes sense to first understand the process on the manual side and investigate whether a standard approach could be adopted before automating the process. This will result in consistency in the approach, and proper adaptation of similarity methods.

6. Conclusions

The research experimented with text similarity functions being cosine similarity, the Jaccard index and the LCSR to determine the one which performs best in SQL query grading. While the LCSR outperformed the other two methods, the results can only be used as a baseline for further experiments considering the various factors that make SQL query similarity different from regular string similarity. Further experiments could include adaptive similarity functions that consider all the other queries submitted to calculate the mark, and semantic similarity functions utilising additional resources and knowledge. These methods, however, can be further informed by how assessors handle and assign marks to different parts of the query, extra components not needed in the query and wrong syntax.

While AI promises to revolutionise the teaching and learning of Computer Science in the future, its methods depend on utilising (presumably correct) existing datasets that, in the query grading case, involve training the models on manually graded queries. Also, it might be some time before AI delivers the automation and they get to be used widely, hence the need to develop some interim methods to at least help partly automate the process, perhaps with some user input involved and feedback as already witnessed in the literature.

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The Development of a new Hospitality Management Information Systems Module using ChatGPT

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Abstract. Academics are required to update and develop new courses on a continuous basis. The ACM provides guidelines for programme and course contents, including curricula guidelines for Information Systems (IS), called IS2020, providing guidelines for difference competency areas for undergraduate programmes. A new Hospitality Management (HM) degree programme was introduced at the Nelson Mandela University in South Africa and a new HM Information Systems module had to be developed for the programme. IS2020 and various international HM course programmes and course outlines were examined, however limited information was available on the course contents of a HM IS module. Artificial Intelligence (AI) is increasingly being integrated into various aspects of education, also referred to as AIED and can assist with course development, the creation of new educational content and pedagogical design. ChatGPT has been used by educators to assist in course outline development, course content creation, aligning course content to learning objectives and developing course materials, such as tutorials and quizzes. The aim of this paper is to illustrate how ChatGPT was used to create the content for a new HM IS 2nd year module. The self-study research methodology was followed in order to reflect on the course development using ChatGPT. An overview of the HM IS module is provided, and a new HM IS course outline and content are presented.

Keywords: ChatGPT, Hospitality Management, Information Systems, Course development.

1. Introduction

Globally, organisations are experiencing a digital transformation, which includes the integration of digital technology into all areas of an organisation, in order to remain competitive [1]. Information Technology (IT) software and hardware applications are essential technologies used in all industries, including the hospitality industry. Employees are required to obtain and develop digital skills and adapt to new technologies, tools and business processes to improve productivity, customer service and provide competitive advantage.

In the hospitality industry, the Internet plays a major role, specifically in marketing, guest relations and reservations [2]. Hotel management software, also referred to as Property Management Software (PMS) are important business applications to manage

all aspects of running a hotel, including Customer Relationship Management (CRM), front and back-office operations, finances and restaurant management applications. Technologies such as artificial intelligence (AI) chatbots can improve guest experiences and the use of robots can lower staff workload and minimise costs.

Educators are continuously required to update and develop new courses that can provide current and future employees with the required skills to function in the digital business environment. In the study fields of Computer Science (CS), Information Systems (IS) and other information technology related fields, the Association for Computing Machinery (ACM), a global educational and scientific organisation, provides curriculum guidelines for educational institutions. In the field of Information Systems, the ACM have released IS2020, the Competency-Based Information Systems Curriculum Guidelines [3]. The guidelines provide curriculum or programme content for undergraduate courses, such as Web and mobile development, project management and business process management.

Digital disruptors, such as AI and large language models (LLM), such as ChatGPT offer opportunities for the development of course materials. Crompton and Burke's [4] systematic literature review on the use of AI in education, revealed that more work needs to be done on the use of ChatGPT. AI has significantly transformed teaching and learning [5] and advances in AI technologies have highlighted educational changes in higher education, particularly the application of AI in Education (AIEd) [6]. Maron and Araci [7] found that ChatGPT was a competent partner, which saved time, structured textual content and assisted as a brainstorming tool.

Course material design is being enhanced with the integration of IT into modules because of the role IT plays in various sectors and business activities [8]. Universities regularly introduce new qualifications, and the Nelson Mandela University recently introduced a new BCom degree programme in Hospitality Management. New qualifications must emphasise interdisciplinary and innovative thinking together with pure specialisation, to prepare students for the world of work [9]. The design of new courses must be collaborative [8].

The Department of Computer Science was requested to develop a new Hospitality Management (HM) Information Systems (IS) 2nd year module that focused on how IT supports the business functions in the hospitality industry. The academics involved in developing the new HM IS module were unfamiliar with the different business functions of a hotel. They consulted the IS2020 course guidelines and international hospitality management qualifications curricula. However, the problem that they faced was that at the time no detailed course content for a HM IS course could be found. It was therefore decided to develop a new HM IS course using ChatGPT. The focus of this paper is to present the new course outline and describe the process, using ChatGPT in the development of the course.

The research objective and research problem are discussed in Section 2. Literature on the use of AI in course development is discussed in Section 3. The research methodology is presented in Section 4 and the HM IS course and topics and example course content generated by ChatGPT are presented in Section 5. The conclusions of this study and future work are discussed in Section 6.

2. The Research Problem and Research Objective

Universities are required to introduce new degree programmes and courses on a regular basis. The Nelson Mandela University introduced a new three year BCom degree in HM and various supporting departments were required to develop new courses or adapt existing courses to be presented as part of the programme. The Department of Computing Sciences was required to develop a new HM IS module and present the module at second-year level as part of the BCom HM degree programme.

The research problem investigated in this study was that the Computer Science departmental staff had limited experience developing an IS/IT module for the HM qualification. Various resources were investigated, including the ACM IS2020 curriculum guidelines, hospitality management literature [10] and similar national and international qualifications. Limited details were available on the IS/IT component of these qualifications.

The objective of this paper was to reflect and report on the development of the new HM IS module, using ChatGPT. ChatGPT has been used effectively for developing course material [11]. The new HM IS course content has been aligned with the aims of the different modules comprising the HM degree programme and it shows how IT can support the different HM functions in the hospitality industry, specifically hotels.

3. Literature Review

Academic programmes have been traditionally divided by discipline, with emphasis on the student developing specialised skills for a particular industry. Shen et al. [12] argue that the efficiency brought on by technologies has shifted the set of skills in high demand from more specialised industry expertise to more cross-disciplinary expertise, which requires a blended approach to course development. Course development has focused on enhancing the practice of lecturers in higher education through a variety of means [13]. Inamorato et al. [14] identified four recurrent obstacles, namely an unwillingness for academics to move away from more traditional methods, a lack of incentivisation: the lack of time in the workload for academics to take part in development opportunities and a lack of institutional infrastructure.

AI tools are revolutionising all sectors, which includes higher education. AIED, which refers to the use of AI in education, can help educational administrators make decisions about course development, pedagogical design and academic transformation [6]. There is a need to increase the academic understanding of AIED [4]. It is necessary to articulate the benefits of AI in transforming education and learning and train faculty on the benefits of using AI, as in this case, as a tool to aid in course material design [16]. Mai, Da and Hanh's [11] systematic literature review indicated that the two topics receiving the most interest in the use of ChatGPT were the development of course material and providing personalised learning experiences.

The rapidly changing global scenario requires higher education institutes to prepare future-ready students [15]. The COVID-19 pandemic has highlighted the important role that professional development for university academics plays in strengthening teaching and learning. A need for new forms of teaching and academic work in general is evident [17]. Planned curriculum design can ensure meaningful, authentic and active learning that nurtures students' ability to be reflective and to self-regulate while acquiring

enhanced thinking skills and abilities [18]. There are a number of digital tools which can assist lecturers and these include Google classroom, Kahoot! Socrative, ZOOM and Padlet.

The development pace and accessibility of AI tools are challenging all areas of design and educators are increasingly under pressure to respond to the AI challenges [19]. AI provides many benefits, but it also has limitations. The challenges include infrastructure requirements, considerations of inclusion and equity, lecturer readiness and preparation and ethical concerns [5]. AI has demonstrated great potential in promoting educational transformation [20]. Additional challenges include ethical challenges regarding data privacy, equity of access to education and the impact on the role of the teacher [22]. AI should be seen as a virtual colleague.

ChatGPT (Generative Pre-trained Transformer) is an AI-powered chatbot by OpenAI [23]. It is a revolutionary tool that responds to enquiries on nearly everything available in the contemporary digital environment. ChatGPT is proficient in multiple programming languages and has the capacity to facilitate multilingual communication. ChatGPT epitomises a significant stride in AI's capacity to comprehend and replicate human-like text [20]. ChatGPT, which is specifically designed for natural language generation and conversation, has exhibited a significant impact in higher education settings [21].

ChatGPT possesses the capacity to construct narratives, emulate dialogues and even engender creative compositions, such as poetry and musical pieces, mirroring its profound comprehension and generative faculties pertaining to human language [20]. ChatGPT has positioned itself as a disruptive technology that is revolutionising the way students are taught, promoted and supported in academic environments and discussions on how this technology can be incorporated into didactic models as an additional resource to complement teaching and learning are abundant [22]. However, the incorporation of ChatGPT into educational settings, has caused mixed reactions [11].

Javaid et al. [23] comment on the benefits of using ChatGPT by educators to design lessons and instructional materials. ChatGPT will make educators more powerful if they learn to use the tool to support their work. Maron and Araci [7] highlighted the weaknesses of using ChatGPT for course development as generic content generation, which required human prompting and manual editing to produce desirable outcomes. Yu [20] comments that ChatGPT's educational abilities show its collaborative value in content generation and knowledge dissemination and that it should be considered for educational progression, however it is not a substitute for conventional learning methods that foster critical thinking and the synthesis of a coherent body of knowledge. ChatGPT is an effective tool for educators to improve their lessons and students' learning, however it will not replace teachers. Instead, they will become more powerful with better hands-on resources [23]. Mai, Da and Hanh [11] indicated that ChatGPT can be effectively used for developing course material. Al-Worafi et al. [24] recommend that ChatGPT be used as a resource rather than relying primarily on its output.

The BCom Hospitality Management degree programme

The Nelson Mandela University in Port Elizabeth, South Africa introduced the Bachelor of Commerce in Hospitality Management (HM) four years ago in the School

of Economics, Development & Tourism. The BCom degree in Hospitality Management has been designed to meet the growing managerial needs of the Southern African hospitality marketplace, especially in the Western and Eastern Cape.

The degree programme aims to provide students with a comprehensive education in aspects of economics, business management, financial accounting, information systems and logistics, operations and marketing management, with a focus on the hospitality and tourism establishments. Students can further get the opportunity to develop practical and operational expertise in the industry. The university envisioned building a hotel school on its 2nd Ave campus. The HM degree programme subjects are listed in Table 1.

Table 1: HM degree programme subjects

Year level	Selected subjects
1 st	End-user computing; Economics, Business Management, Accounting, Food Services.
2 nd	Business Communication, Business Statistics, Applied Nutrition, Applied Food Science, Accommodation Management, Law for Hospitality Managers, Human Resource Management, Hospitality Information Systems, Marketing Management, Logistics & Purchasing Management.
3 rd	Hospitality Financial Management, Hospitality General & Strategic Management, Events Management, Sustainable Hospitality & Tourism Management, International Hospitality Marketing Strategy, Customer Relationship Management.

4. Research Methodology

Self-study is a methodology for studying professional practice [25]. Self-study aims not only to enhance the quality of practice, but also to open up the self-study to public debate in the academic community, contributing to the knowledge base of teacher education [26]. An essential purpose of self-study is linked to the need to ask critical questions about teaching, learning, development and knowledge and to understand the practices of educators' thinking, actions, concerns, challenges and professional development [27].

Self-study is largely about becoming better informed, gaining expanded understanding and an effort to improve oneself as a professional educator and one's own practice. An important aspect of self-study is to search for the "gap" [27]. Self-study research enables practitioners to develop their 'wisdom of practice' [28; 29]. Hauge [27] argues that self-study enables the educator to review and examine their pedagogical thinking and actions. This results in a better understanding and execution of their own practice. Academic Development is an established and key field in higher education and covers both the development of practice in learning, teaching, course development and assessment in higher education [13].

Self-study focuses on an area of practice that is needed to be better understood and developed, both for reflection and sharing [27]. Self-study creates changes and improvements, as is the case with this study wherein a practice is shared and reviewed, which incorporates interaction and feedback from colleagues and students through

review. The gap identified in the development of this HM IS course was the authors' lack of expertise in the HM IS field and specifically the use of AI in course development. The traditional approach to course development was interrogated through self-study. An improved approach emerged, that being the use of ChatGPT as a facilitator in the development of the course.

The ACM (Association for Computing Machinery) and AIS (Association for Information Systems) have been involved in defining various model curricula for computing education, specifically in the field of Information Systems. The IS2020 and other international curricula were studied, however they were of limited use for the design of the course content for the HM IS module. The lecturers involved in the module decided to make use of ChatGPT to create the HM IS course content for the subjects listed in Table 2.

5. Results and discussion

The development of the HM IS module required that the lecturers investigate the different topics addressed in the other modules of the degree programme (Table 2) and then determine how and what IT applications can be used to support these functions. The focus was firstly to determine the functionality of a hotel Property Management Software (PMS) software package and additional applications required and used to support a hospitality business, for example, a hotel.

Table 2: Selected HM degree programme courses

Year	Courses	Purpose
2	Accommodation Management	To provide students with knowledge and understanding and practical, hands-on experience in professional accommodation, housekeeping, front office reception, room service and guest experience management.
2	Human Resource Management	To provide students with the knowledge, skills and understanding of human resource requirements and management in the hospitality industry.
2	Logistics & Purchasing Management	To provide students with the knowledge and understanding of procurement practices for hotels.
3	Events Management	To provide students with the essential knowledge, strategies and skills required to manage the organisation and staging of a small to medium-sized event, like a wedding or banquet.
3	Hospitality Financial Management	To provide students with the knowledge of the functions and requirements for hotel financial management.
3	Customer Relationship Management	To provide students with the knowledge and understanding of effective customer relationship management.
3	Hospitality Marketing Management	To provide students with the knowledge and skills to effectively manage the marketing of a hotel.

5.1. HM IS Lecture topics

The courses, purpose and topics covered in the HM degree programme (Table 2) and the module guides for each course were consulted. The academics developing the HM IS module, mainly used ChatGPT as a source for the course outline development and to familiarise themselves with hospitality topics and hospitality business functionality and applications. They obtained various software applications, including PMS, Apps and videos to support the course presentation and practical components. The different lecture topics are presented in Table 3, which focuses on how IT supports each HM function in a hospitality business, such as a hotel.

Table 3: HM IS lecture topics

Lecture	Topics
Lecture 1: Information Technology for Hospitality Management	<ul style="list-style-type: none"> • IT for Front Office Management • CRM and HRM software • IT for Accommodation, Lodging and Facilities Management • IT for Housekeeping Management
Lecture 2: Hospitality and the Internet	<ul style="list-style-type: none"> • M-Commerce and E-Tourism • Mobile technologies • Social media platforms • Hotel Property Management systems
Lecture 3: Management of Information Resources	<ul style="list-style-type: none"> • Best Hotel management software packages, features, etc. • Hotel reservation systems
Lecture 4: Front and back-office management	<ul style="list-style-type: none"> • Front desk and back-office software functionality • Reservation systems • Room, laundry service and maintenance software
Lecture 5: Customer Relationship Management in Hospitality	<ul style="list-style-type: none"> • Functionality of a hotel CRM system • Sales and workflow automation • The 360-degree customer profile
Lecture 6: Accommodation, Lodging and Facilities Management	<ul style="list-style-type: none"> • Hotel accommodation and lodging management software • Functionality of a facilities management applications • Internet booking systems
Lecture 7: Housekeeping Management	<ul style="list-style-type: none"> • Housekeeping software functionality • Key aspects of local and international guests
Lecture 8: Restaurant, Food and Beverage Management	<ul style="list-style-type: none"> • Restaurant, food and beverage management software functionality • Stock control
Lecture 9: Procurement and Hospitality Finance Management	<ul style="list-style-type: none"> • Hotel procurement management software features • Supplier management software • Hotel financial management software functionality

Lecture 10: Human Resource Management in Hospitality	<ul style="list-style-type: none"> IT for HRM support functions, e.g. recruitment, training, remuneration, etc. HRM software features and functionality for hotels
Lecture 11: Marketing Management in Hospitality	<ul style="list-style-type: none"> Hotel marketing software features and functionality Guest Loyalty Programmes
Lecture 12: IT for Events Management	<ul style="list-style-type: none"> Event management software functionality WHOVA

5.2. Selected ChatGPT HM IS course content examples

ChatGPT was used to provide key aspects of HM topics. In lecture 7 Housekeeping management, ChatGPT identified key aspects, such as staffing and training, cleaning standards, guest room management, room inventory and supplies, quality control and guest services. Housekeeping management software (HKMS), a collaborative task management application that makes it easier and more efficient for housekeeping and service personnel to create, maintain and assign tasks was presented and HKMS functionality was demonstrated for a software application, such as ALICE (Figure 1).

The HM IS practicals focused on software for specific hospitality functions. The 2nd year students were required to make use of ‘demo’ versions of software and investigate and explore the software functionality (Figure 1). Students were also required to use ChatGPT in practical exercises (Figure 2).

ALICE is a hospitality operations software platform offering various solutions, including housekeeping. ALICE: <https://actabl.com/alice/>

Alice Solutions

Housekeeping Increase staff productivity and decrease operating costs with features to improve team insights and communication. Learn More >	Service Delivery Help your staff work together to ensure guests' and team requests are met consistently and on time. Learn More >	Guest Services Keep your front desk to exceed guests' expectations with personalized services at scale. Learn More >	Guest Messaging Communicate with guests the way they prefer with real-time messaging. Learn More >
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1) You are required to investigate the functionality of ALICE and recommend to the manager of the Beach Hotel, should they invest in the software for housekeeping services. Write a 2-page report describing the functionality offered by the various modules of ALICE. (12)

Fig. 1: ALICE housekeeping software

WRHM202 Practical 1
Due: 1 August 2023 @ 22:00

Tasks

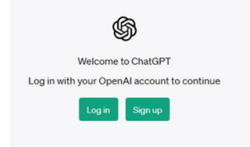
- 1) Log In or Sign up on Open AI ChatGPT - <https://chat.openai.com/>

- 2) Ask ChatGPT: what is the role of "Information Systems for Hospitality Management". Provide a summary (half page) of the response in your own words. (5)
- 3) Ask ChatGPT: what is the role of "Information Technology for Hospitality Management". Compare the results with the findings in Question 2 above. Provide a summary (half page) of the differences in IT for HM in your own words. (5)

Fig. 2: Practical requiring students to use ChatGPT

In lecture 6, Hotel Accommodation Management was introduced. Figure 3 shows the ChatGPT key aspects of hotel accommodation management. They include reservations and bookings, housekeeping, guest services, staff training and management.



Fig. 3: ChatGPT Key aspects of hotel accommodation management.

The topics listed in Figure 3 were discussed in lectures and mapped to different software applications used in industry (Figure 4). In weekly practical sessions, the students for example, were required to make use of software that supported the business functions for accommodation management (Figure 3). The different accommodation software packages are listed in Figure 4.

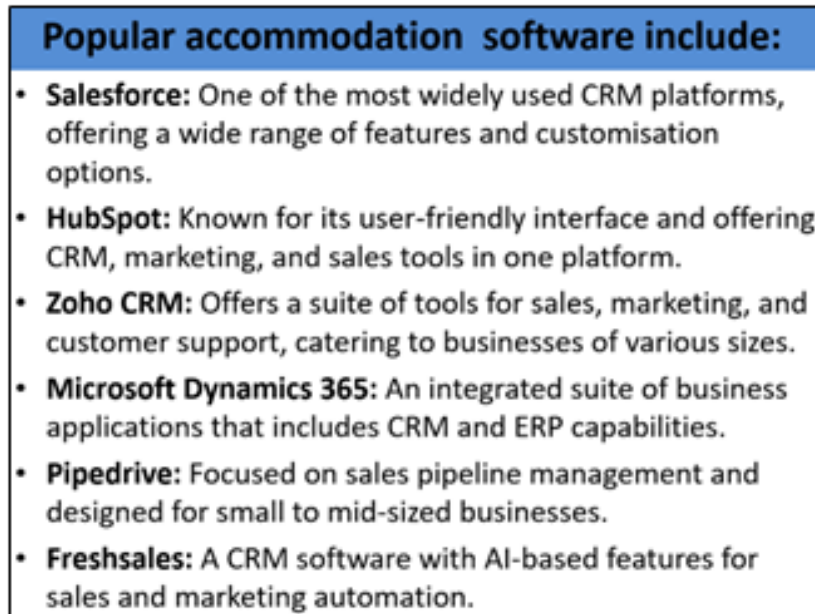


Fig. 4: IT software applications to support hotel accommodation management

ChatGPT was used to generate the key features of hotel marketing management (Figure 5). The emphasis of this lecture was on booking systems, such as Bookings.Com and Trivago. The key features of the booking systems were incorporated into practical exercises and tutorials.

The lecturers further made use of videos demonstrating various aspects of hospitality management during lectures, tutorials and practicals. The following are examples of videos used during tutorials and lectures:

- Tut 3 - Information Technology in Hotels 2.mp4
- Tut 4 - How travel systems talk to each other and Hotel Booking System.mp4
- Tut 8 - Top 5 Restaurant POS Systems for 2023.mp4
- Lecture 8 - GAAP Explained With Examples Mapping Income Statement Lines to GAAP.mp4
- Lecture 10 - Prac 10 - Human resources management in Hotel software.mp4
- Lecture 12 - Whova All in One Event Management.mp4

Special topics included in lectures

The lecturers of the HM IS 2nd year module noticed that the students who registered for the hospitality management qualification, had limited exposure to the hospitality industry. The majority of the students in the class had not stayed in a hotel before and had never travelled internationally. It was therefore decided to include topics, listed below (Figure 6), at the start of each lecture, to expose the students to the hospitality industry.

ChatGPT: Key features of hotel MM
<ul style="list-style-type: none"> • Target Audience Identification: The first step in hotel marketing is identifying the target audience. This can include leisure travelers, business travelers, families, couples, or specific niche markets like luxury travelers, adventure enthusiasts or wellness seekers. • Brand Development: Establishing a strong and appealing hotel brand is essential. This includes defining the hotel's unique value proposition, personality, and positioning in the market. A well-defined brand helps create a lasting impression. • Online Presence: In today's digital age, having a strong online presence is critical. Hotel marketing managers focus on maintaining an informative and visually appealing website, optimising it for search engines (SEO), and utilising social media platforms to engage with potential guests. • Online Booking Systems: Effective hotel marketing involves providing convenient online booking options. Managers need to ensure that the booking process on their website is user-friendly and secure.
ChatGPT: Key features of hotel MM
<ul style="list-style-type: none"> • Distribution Channels: Hoteliers often work with various distribution channels, including online travel agencies (OTAs), global distribution systems (GDS) and direct bookings. Managing relationships with these channels and optimising distribution strategies is a crucial part of hotel marketing. • Content Marketing: Creating and sharing relevant, engaging content is a powerful marketing tool for hotels. This can include blog posts, videos, virtual tours, and user-generated content to showcase the property and local attractions. • Social Media Marketing: Hotels leverage social media platforms like Facebook, Instagram, and Twitter to connect with potential guests, share updates, run promotions and respond to guest reviews and inquiries. • Email Marketing: Building and maintaining a mailing list of past and potential guests allows for personalised communication, special offers and promotions.

Fig. 5: ChatGPT Key aspects of hotel marketing management.

The discussions focused on the additional IT technologies and applications required to support the following hospitality businesses:

- The role of cruise liners in the hospitality industry;
- Hotel trains in the hospitality industry;
- The role of ferries in the hospitality industry;
- Game lodges and wine farms;
- The Ice hotel and under-water hotels;
- Religious tourism; and
- Wedding destinations, Conferences, Computer expos and Banquets.

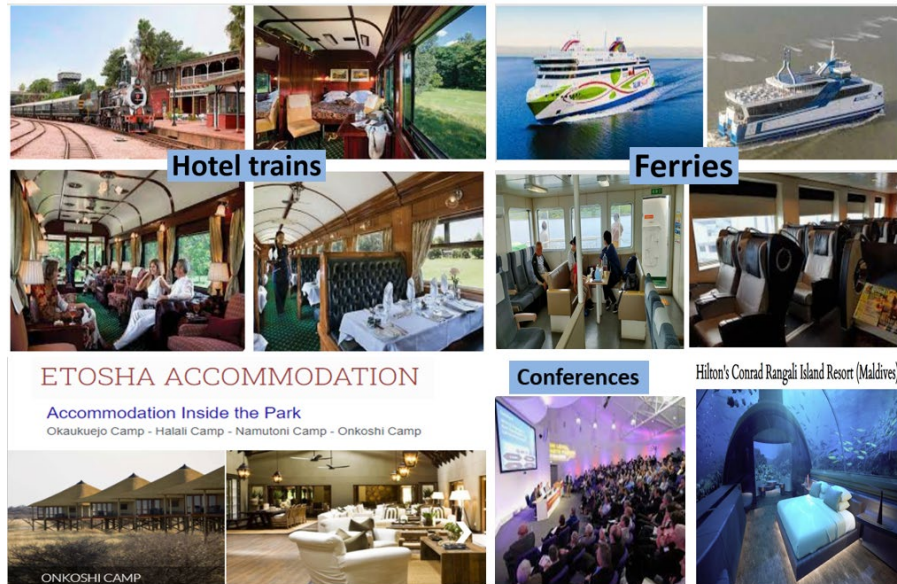


Fig. 6: Additional topics covered in the HMIS202 module.

6. Conclusions and Future Research

The effect of curriculum reform in higher education has been to transform the way programmes and courses are developed adding significant new demands to the learning and teaching roles of individual faculty members [8]. AI provides opportunities for universities to offer new courses and helps lecturers develop activities and material that better suit the needs of students [5]. AI has had a significant impact on education in many areas including the creation of more intelligent content [22].

The introduction of new qualifications and courses requires university CS, IS and other related IT departments to continuously develop and upgrade courses. New courses can be developed using the ACM curriculum guidelines, such as IS2020. New courses not covered by these guidelines can be developed using AI tools, such as ChatGPT. ChatGPT has been used in the past years to assist in the development of new course material [11].

In this study, ChatGPT was used for the development of the new HM IS module presented as part of the BCom Hospitality Management programme at the Nelson Mandela University. The Department of Computer Science was required to develop a 2nd year HS IS course that focused on how IT supported the different business functions, specifically for a hotel. ChatGPT was used to generate hospitality-related topics and the authors then linked the topics with IT applications and software available in industry.

The HM IS course provided BCom students with the opportunity to be exposed to different IT tools and applications used in the hotel industry and related hospitality and tourism businesses. The academics who developed the course made use of ChatGPT to identify the different business functions performed in a hotel, such as CRM, marketing and the use of hotel management systems or PMS. The study provided an association

between hospitality management topics, such as accommodation management and marketing management and the software that supports these functions (Table 3).

Self-study research enables the educator to review and examine their pedagogical thinking and actions and results in a better understanding and execution of their own practice [27]. The lecturers who developed and presented the HM IS module used ChatGPT to assist in self-study research, in order to access published information on the Internet and gained a deeper understanding of the topics being presented. The lecturers found that ChatGPT was a competent partner, which saved time, structured textual content and assisted as a brainstorming tool, supporting Maron and Araci [7] observations.

The student feedback received was very positive, with students indicating that they gained valuable knowledge and understanding of how IT supports the hospitality industry business functions. Future work will focus on the writing of a book entitled “IT for Hospitality Management”, focusing on how IT can support all the functions in the hospitality industry.

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Deconstructing Constructive Alignment: The Design of a Postgraduate Diploma in Cybersecurity

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Abstract. The global cybersecurity skills gap represents a critical challenge in our increasingly digital world. The rapid advancements in technology and the surge in cyber threats have resulted in a widening chasm between the demand for skilled cybersecurity professionals and the available talent pool to meet it. In response to this, the Nelson Mandela University curriculaled a Postgraduate Diploma in Cybersecurity. The approval of the qualification by the South African Qualifications Authority (SAQA) and the Council for Higher Education (CHE) included a pre-defined set of Course learning outcomes (CLOs) and Module intended learning outcomes (MILOs). Constructive alignment, being an outcomes-based approach, was chosen as a relevant approach for designing the qualification to ensure that these pre-defined course learning outcomes and module-intended learning outcomes are met. This paper deconstructs the various components of constructive alignment and describes how these were used in the design of the qualification through reflective practice. The authors were all actively involved in the design of the qualification as module instructional designers. The benefits of this approach were realised through collaborative workshops and the sharing of ideas, resulting in all module instructional designers being confident that their modules align with the pre-defined course learning outcomes and the module's intended learning outcomes.

Keywords: Postgraduate Diploma in Cybersecurity; Curriculum Design; Constructive Alignment; Reflective Practice.

1. Introduction

Cybersecurity professionals worldwide face a constantly changing threat landscape with data breaches in various sectors eroding public trust in cybersecurity. Emerging consumer products like wearables and self-driving cars, along with interconnected critical infrastructure, pose new risks to public safety, privacy, and the economy. In the 2017 Global Information Security Workforce Study Benchmarking Workforce Capacity and Response to Cyber Risk [1], two-thirds of the 19 641 cybersecurity professionals, representing 170 countries, indicated the lack of sufficiently skilled cybersecurity workers to meet the cybersecurity challenges within their organisations.

Unfortunately, South Africa is currently one of the largest targets for hackers and cyber terrorists in the world. With the increase in such cyber threats, there is a growing

need and demand for professionals with the requisite cybersecurity skills and knowledge to combat and mitigate these threats [2].

The Postgraduate Diploma in Cybersecurity at the Nelson Mandela University therefore addresses the need for providing a qualification that specialises in Cybersecurity at a postgraduate level (NQF Level 8). The purpose of this qualification is to provide graduates with the skills to develop and implement cybersecurity policies and measures within an organisation, to develop in-depth disciplinary skills in cybersecurity, and to perform research in the cybersecurity field. The design of the qualification was done by experienced academic staff in consultation with subject matter experts and industry partners.

The Course learning outcomes (CLOs) of the Postgraduate Diploma in Cybersecurity and the intended outcomes of the modules (MILOs) were clearly defined during the high-level design of the qualification. However, the problem addressed by this paper is that module planning often begins with the identification of content/subject matter, with little initial attention given to the alignment of the assessment tasks and learning activities to the learning outcomes.

The purpose of this paper is, therefore, to reflect on the design of the Postgraduate Diploma in Cybersecurity at the Nelson Mandela University. This design took a constructive alignment approach. The idea behind constructive alignment is that when all these components are aligned, students are more likely to engage in deep learning, leading to better understanding and knowledge retention.

Section 2 briefly describes reflective practice as it relates to this paper with the rationale for the qualification being discussed in Section 3. Section 4 introduces constructive alignment and its key components, while Section 5 discusses these components within the context of the Postgraduate Diploma in Cybersecurity. Section 6 then contextualises this further for ‘ICHF402 – Cyber Safety’, a specific module within the qualification and Section 7 concludes the paper.

2. Reflective Practice as the Research Method

Reflective practice was used as the research method for this paper, reflecting on the design of the Postgraduate Diploma in Cybersecurity at the Nelson Mandela University. Donald Schön, a prominent educational theorist, emphasised the essence of reflective practice in his work [3]. He argued that reflective practice is essential for professional growth and development.

More recently, Bilous et al. [4] described how they used reflective practice as a research method for co-creating the curriculum with international partner organisations. They state that “*reflection in its many forms has the potential to be used as a method both in the development of curriculum and for participatory research*”.

The co-creators of the curriculum in our case were experienced academics within the School of Information Technology, taking on the role of module instructional designers. These academics included four professors and two senior lecturers, with over 100 years of combined academic experience. We actively engaged with each other in the design of the curriculum through various face-to-face and online workshops by systematically deconstructing the various components of constructive alignment as described in this paper.

3. Rationale for the Qualification

The ACM/IEEE Information Technology Curricula 2017 [5] has included cybersecurity as a key driving force about information technology innovations. It states that cybersecurity advances are essential to preserve the internet's societal and economic benefits. A 2015 survey conducted by the IT2017 Task Group accurately predicted that cybersecurity skills would be in high demand by the mid-2020s. Therefore, the ACM/IEEE Information Technology Curricula 2017 [5] proposed that cybersecurity be integrated into all information technology curricula and considers Cybersecurity Principles as an essential IT domain.

Cybersecurity is a computing-based discipline involving technology, people, information and organisational processes to enable assured operations in the context of adversaries. It involves creating, operationing, analysing and testing secure computer systems. It is an interdisciplinary course of study that includes aspects of law, policy, human factors, ethics and risk management [6].

According to Frost and Sullivan [1], the world faces a growing workforce shortage of qualified cybersecurity professionals and practitioners. The cybersecurity workforce demand is acute, immediate, and growing. This trend also pertains to South Africa. This qualification was therefore developed to meet the need for trained cybersecurity professionals by enabling graduates to confidently and professionally address cybersecurity risks within an organisation. It enables the students to develop integrated competencies in cybersecurity by examining the issues within cybersecurity relating to technology, people, information and organisational processes.

Furthermore, this Postgraduate Diploma fills the qualification gap within the School of Information Technology at the Nelson Mandela University, as the Bachelor of Technology (BTech) in Information Technology was phased out in 2019. In 2020, the Advanced Diploma in Information Technology partially replaced the BTech, providing an NQF level 7 qualification. Since 2020, the number of students registered for the Advanced Diploma has exceeded that of the BTech ranging between 180 and 200 students each year. Those who achieve an average of at least 60% meet the entry requirements for the Postgraduate Diploma in Cybersecurity. This Postgraduate Diploma, therefore, allows qualifying Advanced Diploma students the opportunity to do an NQF level 8 qualification that can give them entrance into a Master's in Information Technology specialising in cybersecurity. In addition, this qualification could potentially allow working professionals to strengthen and deepen their knowledge in the Cybersecurity field.

4. Constructive Alignment

Constructive alignment was first introduced by Professor John Biggs, a prominent educational psychologist, in the 1990s. Biggs [7] proposed this framework as a means to enhance the quality of teaching and learning by aligning various components of the curriculum. Since its introduction, constructive alignment has gained widespread recognition and adoption in educational institutions worldwide.

Constructive alignment is an outcomes-based, learner-centred approach to teaching in which the learning outcomes that students should achieve are clearly defined before teaching takes place [8]. It provides an effective framework for systematically designing educational courses to align the course learning outcomes and related module intended learning outcomes are aligned. This is achieved through designing assessment tasks that are informed by the learning outcomes, against which the assessment tasks will be evaluated. After that, the learning activities, guided by the intended outcomes, are designed to ensure that they support the assessment tasks, together with relevant content and learning resources. All these elements must support and reinforce each other.

Wang et al. [9] explored Bigg's constructive alignment in course design and its impact on students' learning approaches. Their study was consistent with similar studies, providing evidence that "*a more constructively aligned teaching and learning environment would lead students to adjust their learning approaches in a way that a more deep situational learning approach would be employed*". However, they recognise that alignment is often lacking and taken for granted and that instructors and course designers should pay more attention to the proper implementation of constructive alignment [9].

The idea behind constructive alignment is that when all these components are aligned, students are more likely to engage in deep learning, which leads to a better understanding and retention of the material. In essence, constructive alignment ensures that [8]:

- Students are clear about what they are expected to learn;
- the teaching methods support the achievement of the learning outcomes; and
- the assessment tasks genuinely assess the extent to which the outcomes have been achieved.

The main components of constructive alignment, as shown in Figure 1, are defined as follows:

- **Learning Outcomes (LOs):** These are clear statements that specify what students should know, understand, or be able to do by the end of a course or a specific instructional period. They serve as the foundation for the entire teaching and learning process. In constructive alignment there are two main types of learning outcomes, namely: course learning outcomes (CLOs) and module intended learning outcomes (MILOS).
- **Assessment Tasks (ATs):** These are designed to evaluate whether students have achieved the learning outcomes. Importantly, the assessment tasks should reflect the learning and understanding that the learning activities are trying to promote. For instance, if a learning outcome concerns critical thinking, the assessment should test students' critical thinking skills, not just rote memorisation.
- **Learning Activities (LAs):** Once the learning outcomes are established, educators select learning activities to help students achieve those outcomes. This could include lectures, group discussions, practical exercises, field trips, and more. The key is to choose activities that actively engage students and promote deep learning.

- **Content and Learning Resources (CLRs):** Content and learning resources should be thoughtfully selected and designed to support the learning activities and assessment tasks to ensure that students achieve the module's intended learning outcomes, thereby contributing to constructive alignment in the teaching and learning process.

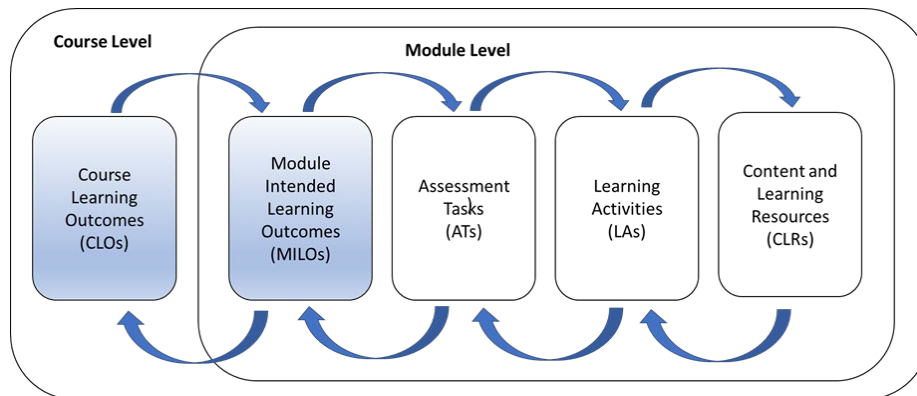


Fig. 1. Components of Constructive Alignments (adapted from [8] and [10])

The framework of constructive alignment, as presented in Figure 1, clearly shows our approach to module design within the Postgraduate Diploma in Cybersecurity. The arrows from left to right, above the components, indicate the *informing* role of the multiple components, while the arrows from right to left, below the components, indicate the *supporting* role of the various components. The course learning outcomes (CLOs) and module-intended learning outcomes (MILOs) were pre-defined as part of the approval of the qualification with the South African Qualifications Authority (SAQA) and the Council for Higher Education (CHE).

The challenge for the module instructional designers was to design the details of the modules, paying attention to the three remaining components as follows:

- To design assessment tasks (ATs) to measure the attainment of the module intended learning outcomes (MILOs). These ATs were therefore informed by the MILOs and supported by the learning activities.
- To plan learning activities (LAs) to enable students to develop the skills, knowledge and understanding described in the module intended learning outcomes (MILOs) and evaluated by the assessment tasks (ATs). These LAs were therefore informed by the ATs and supported by the CLRs.
- To choose relevant content and learning resources (CLRs) including topics/examples/case studies and scenarios to support the learning activities (LAs). These CLRs were therefore informed by the LAs, ensuring that they fully support the related LAs.

5. Constructive Alignment in the Postgraduate Diploma in Cybersecurity

This section describes the components of constructive alignment within the context of the Postgraduate Diploma in Cybersecurity. The module instructional designers were cognizant of the fact that alignment is often taken for granted and the need for more attention to be given to the proper implementation of constructive alignment as emphasised by Wang et al. [9]. It was agreed that the more traditional approach of using one or two prescribed textbooks for each module would not ensure that students would meet the learning outcomes.

5.1. Course learning outcomes (CLOs)

The course learning outcomes were defined during the curriculum process which started in 2018. These were indicated in the curriculum documents as exit-level outcomes (ELOs). For this paper, ELOs are referred to as CLOs as defined by constructive alignment. Table 1 indicates the six-course learning outcomes (CLOs) identified for the Postgraduate Diploma in Cybersecurity.

To ensure their international comparability, the following international qualifications and resources were reviewed to help articulate these outcomes:

- The NMIT Post-Graduate Diploma in IT Security Management, Nelson Marlborough Institute of Technology (New Zealand).
- The Postgraduate Diploma in Computer Science for Cyber Security, Oxford (United Kingdom).
- The Postgraduate Diploma in Computing in Cybersecurity, Letterkenny Institute of Technology (Ireland).
- The ACM/IEEE Cybersecurity Curricula 2017.

Table 1. Course Learning Outcomes (CLOs)

CLO#	Description
CLO1	Apply the theory and practice of Information and Cybersecurity in IT in an organisation via a problem-based case study application
CLO2	Integrate Culture and Awareness into an Information and Cybersecurity strategy
CLO3	Conduct a systematic investigation into an Information and Cybersecurity topic
CLO4	Examine how Information and Cybersecurity is managed and governed in a provided IT context
CLO5	Identify and manage the risks of cyber threats by using a range of specialised knowledge, skills, frameworks, technologies and ethical standards associated with Information and Cybersecurity in a given/provided scenario
CLO6	Construct an effective communication/report related to a provided information and cybersecurity context/scenario

Having defined the CLOs, the various modules making up the 120 credits of the qualification were determined ensuring international comparability and alignment with the CLOs. The mapping of CLOs to modules helps to ensure that all CLOs are addressed in a balanced way, that any gaps can be covered and that weak alignment can be addressed. Table 2 indicates the eight modules, their purpose, the number of credits, and the CLOs aligned with each module.

Table 2. Postgraduate Diploma in Cybersecurity Modules

Module	Purpose	Credits	CLO
Information and Cybersecurity Principles [ICYB401]	This module prepares students to understand and apply the theoretical and conceptual principles of cybersecurity.	15	CLO1, CLO2, CLO4, CLO5
Professional Skills in Cybersecurity [ICCT401]	This module provides students with professional behaviour and communication for a profession in cybersecurity. Students will be enabled to communicate and apply critical thinking to identify and solve information and cybersecurity problems. They will be enabled to approach the problems consistently and systematically and to professionally communicate ideas and arguments in writing and verbally.	15	CLO6
Research Methodology [ICYP401]	This module prepares students to conduct research within the field of Information Technology. Students are therefore enabled to investigate and report on information and cybersecurity problems in a systematic, scientific way, either in industry or academia.	12	CLO3
Research Report [ICYR402]	This module equips students with the competence to write a research report by following the academic research process and producing a research report in compliance with accepted editorial standards for academic writing	18	CLO3
Information Security Management [ICYI402]	This module develops an understanding of information security management required to protect organisations from information and cyber threats and manage the risk to support the successful accomplishment of the organisation's mission, while considering business continuity.	15	CLO1, CLO2, CLO4, CLO5
Information Security Governance [ISGO402]	This module prepares students to understand information security governance. Governance is the responsibility of senior management to ensure the effective implementation of	15	CLO1, CLO2, CLO4, CLO5

	strategic planning, risk management and regulatory compliance usually using comprehensive managerial policy, plans, programs and controls to secure the information of the organisation. This module frames the implementation of security governance and policy within global and national laws, regulations and standards.		
Cyber Safety [ICHF402]	This module is the study of human behaviour as it relates to cybersecurity and focuses on protecting individuals' data and privacy in the context of organisations (as employees) and personal life.	15	CLO1, CLO2, CLO3, CLO5
Technical Aspects in Information and Cybersecurity [ITAI402]	This module introduces students to selected technical aspects of information and cybersecurity. Coverage includes network security concepts and tools, including the technical approaches and tools hackers would use when attacking organisations. Students will also be introduced to the challenges of secure software development.	15	CLO5
TOTAL		120	

5.2. Module intended learning outcomes (MILOs)

Having determined the modules comprising the qualification and the alignment to the CLOs, the next step was determining the module intended learning outcomes (MILOs) as shown in Table 3. This required various cycles of review and refinement to ensure that the intended learning outcomes reflected *what* the students would be required to achieve within each module. MILOs are specified in terms of the knowledge, skills and general competencies that students should demonstrate.

Each of the MILOs adhered to the following:

- written from a student's perspective,
- contained a verb that demonstrates the appropriate level of knowledge, skill or general competency, and
- align with one or more CLOs.

It was important to note that MILOs are not topics but rather embody the higher-level knowledge/skill/competence that may be taught through several related topics.

Table 3. Module intended learning outcomes [MILOs]

Module	Intended Learning Outcomes [MILOs]
Information and Cybersecurity Principles [ICYB401]	<ul style="list-style-type: none"> • Identify risks, threats and vulnerabilities for a given case study. • Recommend security measures for a given context. The confidentiality, integrity, and availability of information

	<p>knowledge are used to recommend security measures for a given context.</p> <ul style="list-style-type: none"> • Analyse the benefits and challenges of various access control methods and management and relate them to a case study. • Motivate how the use of cryptography can be used to protect information. • Explain the concept of privacy and identify examples of personally identifiable information. • Explain how law and ethics relate to information and cybersecurity. • Analyse the importance of security education, training and awareness programs within organisations.
Professional Skills in Cybersecurity [ICCT401]	<ul style="list-style-type: none"> • Solve a problem by using concepts related to analytical and systems thinking for information and cybersecurity. • Determine the importance and relevance of arguments and ideas by creating a solution to a specific problem. • Present an idea/solution and its arguments to an Information and cybersecurity problem using a professional presentation and report. • Evaluate several strategies for effective professional communication in writing and in speaking to create a presentation and report. • Create a well-organised technical report that is structured according to acceptable standards. • Analyse and describe the role of communications within IT as well as in building relationships with the organisations.
Research Methodology [ICYP401]	<ul style="list-style-type: none"> • Identify and solve problems in which responses display that responsible decisions using critical and creative thinking have been made. • Formulate the research problem and objectives. • Collect, analyse, organise and critically evaluate information. • Communicate effectively using visual, mathematical and language skills in the modes of oral and/or written presentation. • Identify appropriate research methods for a specific solution for a research problem. • Write a research proposal in the appropriate format.
Research Report [ICYR402]	<ul style="list-style-type: none"> • Collect, analyse, organise and critically evaluate information for a report. • Determine the ethical implications of the investigation • Compile a scientifically sound research report.

	<ul style="list-style-type: none"> • Write up and present a research report with recommendations.
Information Security Management [ICYI402]	<ul style="list-style-type: none"> • Critique on information security management and its dimensions. • Analyse IT risk management and its role in an organisation. • Develop a security management program to mitigate information risk to an acceptable level. • Examine ICT readiness for business continuity. • Propose options for ICT readiness for business continuity for a provided case study. • Identify and analyse, using a case study, how an enterprise manages and responds effectively to unexpected events that may adversely affect its information assets and/or its ability to operate.
Information Security Governance [ISGO402]	<ul style="list-style-type: none"> • Explain information security governance. • Investigate the information security strategy. • Critically evaluate information security policy and its role in information and cybersecurity programs. • Critique regulatory compliance of global and national laws, regulations and standards, relating to information and cybersecurity governance.
Cyber Safety [ICHF402]	<ul style="list-style-type: none"> • Analyse the types of social engineering attacks and the detection or mitigation thereof. • Detect a social engineering attack and how it is mitigated. • Identify and analyse social media privacy concerns. • Provide a guide to the individual responsibilities to protect and mitigate against cyber threats and cyberattacks. • Design relevant information and cybersecurity Education, training and awareness initiative.
Technical Aspects in Information and Cybersecurity [ITAI402]	<ul style="list-style-type: none"> • Evaluate network vulnerabilities and identify mitigation strategies. • Identify and examine selected tools that are utilised by hackers in attacking systems. • Assess the challenges with secure software development.

As mentioned, the course learning outcomes (CLOs) as highlighted in Section 5.1, and the module intended learning outcomes, presented in this section, were defined during the qualification approval process.

The module instructional designers, therefore, needed to pay attention to the remaining three components of constructive alignment, namely the assessment tasks (ATs), learning activities (LAs) and the content and learning resources (CLRs). This was done through collaboration to ensure alignment and a consistent approach across the qualification. Various online and in-person workshops were held and documents were shared on the Microsoft Teams platforms. We deemed it important that all instructional designers know what was planned for the overall qualification, rather than

just being concerned with their specific modules. The workshops assisted us in identifying possible touch points and overlaps across the various modules to ensure students build a more comprehensive, integrative mental model of the qualification and, thus, the subject matter.

5.3. Assessment tasks (ATs)

Designing assessment tasks (ATs) early in the curriculum process, helps to ensure that the assessment is reliable, in that it supports the consistent assessment of students over time; valid, in that it assesses what it claims to assess (the relevant MILOs); and transparent, in that students will know what is expected of them.

Assessments are done for several reasons. Firstly, to determine whether a student has achieved a particular learning outcome. We can refer to these as *summative assessments* or say that it is the **assessment of learning**. Secondly, to stimulate the learning behaviour of a student. We also call this *formative assessment*. To be formative, we must ensure students get timely and helpful feedback. We can say that it is an **assessment for learning**. Thirdly, to stimulate metacognition in students. Essentially students are required to think about their own learning more explicitly. We say this is **assessment as learning**. The assessment tasks, as specified in constructive alignment, refer to *summative assessments*.

Having determined the module intended learning outcomes (MILOs) as indicated in Table 3, each module required that the assessment tasks (ATs) be designed to evaluate whether students have achieved the MILOs. ATs must be carefully chosen and created to ensure students are not over-assessed., while still ensuring the MILOs are met. If one considers a MILO, sometimes the assessment task seems apparent. However, an assessment task does not have to assess just one MILO, nor is a MILO only assessed through one assessment task. Although it may seem relatively straightforward to derive an assessment task from a MILO, in many cases, this might not be the case. Furthermore, it may be appropriate to have an assessment task that assesses multiple CLOs, either fully or partially.

The defined ATs inform the LAs which reflect the learning and understanding required to carry out the ATs. Summative assessments generally included tests, exams, presentations, portfolios and reports. Such assessments are generally considered fair if students' development is supported through appropriate LAs, including formative assessment opportunities.

5.4. Learning activities (LAs)

Once we know how we will assess the MILOs, we can design the learning activities (LAs). To do this, we consider the assessment tasks (ATs) by developing the criteria used for the ATs which results in detailed requirements or “next level” learning outcomes. These learning outcomes will inform us which LAs must be in place. The assessment criteria also help bring clarity to the students. We may, for example, do this using a rubric where each of the “next level” learning outcomes contributes one or more items to the rubric.

Having determined the assessment tasks (ATs), it was then necessary to define the learning activities (LAs) to help students achieve the intended learning outcomes, evaluated through the assessment tasks (ATs). These learning activities generally include lectures, group discussions, practical exercises, quizzes, pre-recorded lectures,

case studies and scenarios to ensure that students actively engage in the activities and to promote deep learning. In constructive alignment, the learning activities must be planned with the assessment plan and opportunities for additional formative feedback must be identified. These additional formative feedback opportunities may result in adjusting the teaching and learning plan to incorporate more learning activities with inherent feedback.

5.5. Content and learning resources (CLRs)

Having developed appropriate learning activities (LAs) informed by the assessment tasks (ATs), relevant content and learning resources (CLRs) were identified to support the learning activities. These resources included using Perlego, which provides access to over 1 million academic and non-fiction titles, relevant textbooks, videos and academic publications. Some resources were identified as relevant to multiple modules, such as various ISO and NIST standards relating to information security and cybersecurity.

The following section discusses the detailed use of constructive alignment for 'ICHF402 - Cyber Safety', one of the second-semester modules in the Postgraduate Diploma in Cybersecurity.

6. Using Constructive Alignment – ICHF402 – Cyber Safety

As indicated in Table 2, 'Cyber Safety' is one of the modules offered within the Postgraduate Diploma in Cybersecurity qualification. The purpose of the module is the study of human behaviour as it relates to cybersecurity. It focuses on protecting individuals' data and privacy in the context of organisations (as employees) and personal life.

Table 4 shows the course learning outcomes (CLOs) of the Postgraduate Diploma in Cybersecurity mapped to the module intended learning outcomes (MILOs) of 'ICHF402 - Cyber Safety'. As can be seen from Table 4, ICHF402 has five modules intended learning outcomes (MILOs). These MILOs are clear statements that specify what students should know and understand by the end of ICHF402 in the context of Cyber Safety. They are the foundation for assessment tasks and learning activities.

As seen in Table 2, ICHF402 maps to CLO1, CLO2, CLO3 and CLO5. Further to this, as seen in Table 4, '*CLO1: Apply the theory and practice of Information and Cybersecurity in IT in an organisation via a problem-based case study application*' maps to MILO2 and MILO5 of ICHF402. Both MILO2 and MILO5 are linked to case studies. These case studies aimed to allow students to apply knowledge to demonstrate how theoretical concepts could be implemented in 'simulated' real-world situations. As seen in Table 4, the intersection of CLO1 and MILO2 is highlighted in grey, as this mapping will be discussed in more detail in the remainder of this section.

Table 4. Mapping of CLOs to the MILOs of ICHF402

		MILO1 Analyse the types of social engineering attacks and the detection or mitigation thereof	MILO2 Detect a social engineering attack and how it is mitigated.	MILO3 Identify and analyse Social media privacy concerns	MILO4 Provide a guide to the individual responsibilities to protect and mitigate against cyberthreats and cyberattacks	MILO5 Design relevant Information and Cybersecurity Education, training and awareness initiative
CLO1	Apply the theory and practice of Information and Cybersecurity in IT in an organisation via a problem-based case study application		X			X
CLO2	Integrate Culture and Awareness into an Information and Cybersecurity strategy.	X		X		X
CLO3	Conduct a systematic investigation into an Information and Cybersecurity topic				X	X
CLO5	Identify and manage the risks of cyber threats by using a range of specialised knowledge, skills, frameworks, technologies and ethical standards associated with Information and Cybersecurity in a given/provided scenario		X	X		X

Figure 2 shows the constructive alignment flow from CLO1 to ‘MILO2: Detect a social engineering attack and how it is mitigated’ to certain of the assessment tasks and learning activities for this module. It must be noted that Figure 2 only shows one example of the link between a specific CLO1 and MILO2 and one of the assessment tasks (AT5) and the associated learning activities. Many more assessment tasks, assessment criteria and learning activities are necessary to achieve MILO1 to MILO5 for ‘ICHF402 – Cyber Safety’.

One of the assessment tasks required to achieve MILO2 is ‘AT5: Presentation of scenario-based Case Study: Becoming a Social Engineer’. The number five in AT5 indicates that this is one of numerous (eight) summative and formative assessment categories needed to achieve the MILOs of ICHF402. The dotted arrow between MILO2 and AT5 indicates that the completion of AT5 partially achieves MILO2.

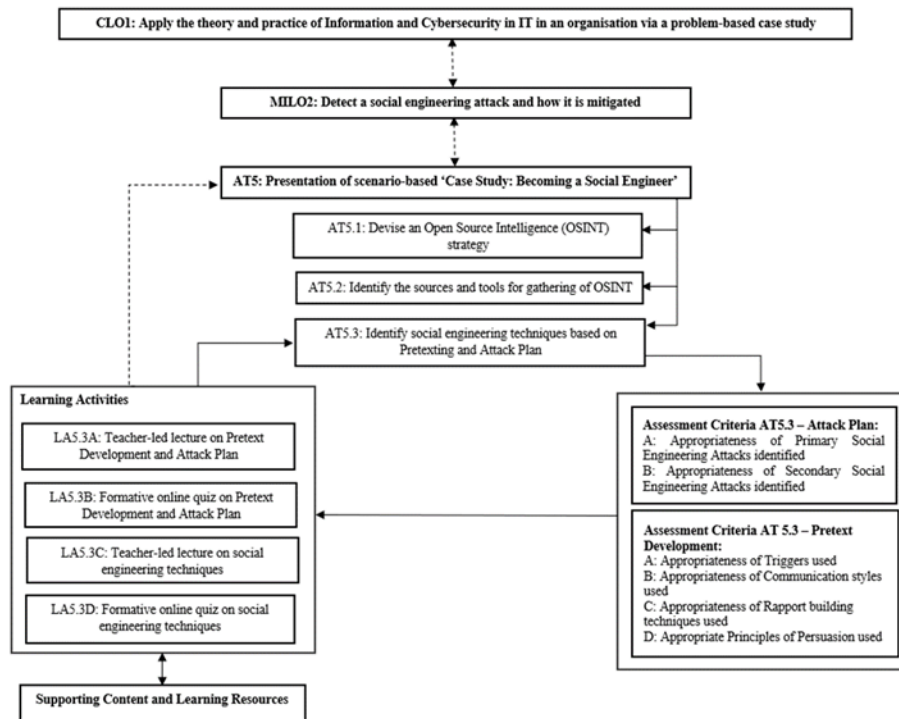


Fig. 2. The use of constructive alignment for the 'ICHF402 – Cyber Safety' module

AT5 entails a presentation by student groups to discuss ICHF402's first Case Study as a summative form of assessment. The presentation determines the students' mastery of the Case Study concepts. This assessment task consists of AT5.1, AT5.2 and AT5.3 – all of which must be satisfactorily completed in order to achieve AT5. AT5.3 is further detailed in Figure 2, which shows the 'Assessment Criteria AT5.3 – Attack Plan' and 'Assessment Criteria AT5.3 – Pretext Development' linked to AT5.3. Each of these assessment criteria detail the rubric used to determine whether AT5.3 is achieved.

Using constructive alignment, only once the assessment tasks and associated assessment criteria were determined, could the learning activities, LA5.3A, LA5.3B, LA5.3C and LA5.3D, be decided upon. These learning activities, needed to support the achievement of AT5.3, included teacher-led lectures and formative online quizzes to monitor student progress and provide ongoing feedback throughout the learning process. Once the learning activities were determined, the content and learning resources were identified, informed by the learning activities and required to support those learning activities. As shown in Figure 2, the learning activities, LA1.3A to LA1.3D, support the achievement of AT1.3 and partially support the achievement of AT5.

7. Conclusions

This paper presented the design of a Postgraduate Qualification in Cybersecurity using a constructive alignment approach. This approach was deemed relevant because it is outcomes-based and the course learning outcomes and module-intended learning outcomes were clearly defined during the approval process with SAQA and the CHE.

This approach ensured alignment of all modules and their respective intended learning outcomes, assessment tasks and learning activities, thereby achieving the course learning outcomes. Further benefits from this approach were realised through the collaborative workshops and sharing of ideas, resulting in all module instructional designers being confident that their modules align with the pre-defined course learning outcomes and module intended learning outcomes.

One of the challenges encountered was the lack of time in designing each module. The development of the content and learning resources, in most cases, took place during the semester in which the module was offered. It would have been advantageous to have additional time to develop the content and learning resources in detail before the start of the qualification. Despite this challenge, the module instructional designers acknowledged the value of explicitly paying attention to constructive alignment in the design of their modules early in the process.

Furthermore, by teaching the modules, continuous improvement will be achieved through reflection and the ongoing refinement of the assessment tasks and learning activities, as well as ensuring that the supporting content and learning resources remain relevant and up to date.

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Reflections from the Inaugural Year of the Postgraduate Diploma in Cybersecurity: Towards Continuous Improvement

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Abstract. As cyber threats increase and the world becomes more dependent on technology, there is a high demand for more cybersecurity experts. This paper discusses the inaugural year of the Postgraduate Diploma in Cybersecurity at Nelson Mandela University, an initiative aimed at contributing to the closure of the global cybersecurity skills gap. By providing a detailed curriculum that encompasses both theoretical knowledge and practical applications, the program seeks to equip graduates with the skills necessary to address complex cybersecurity challenges. Through a reflective analysis based on a SWOT framework, this study critically assesses the first year of offering the program, identifying strengths, weaknesses, opportunities for growth, and potential threats. This analysis is crucial for the program's continuous adaptation and improvement, ensuring it remains aligned with the latest technological advancements and industry demands. By sharing insights and lessons learned, this paper aims to contribute to the broader discussion on enhancing cybersecurity education and effectively responding to the critical need for skilled professionals in the cybersecurity field.

Keywords: Constructive Alignment, Reflections, Cybersecurity Curriculum

1. Introduction

The increasing number of cyber threats and our growing reliance on technology highlight a critical need for more cybersecurity professionals worldwide. According to a 2023 report by [1], there's a pressing requirement to significantly expand the cybersecurity workforce to safeguard organisations and their vital assets from increasingly sophisticated threats. This skills shortage in cybersecurity is not only a challenge for the technology industry but is also considered a significant risk to global economic stability and societal safety [2].

Recognising the crucial role of education in addressing this challenge, universities and colleges worldwide have begun to offer specialised cybersecurity programs. These educational initiatives aim to equip a new generation of professionals with the comprehensive skills and knowledge required to navigate and protect our digital environments. In this context, Nelson Mandela University introduced a Postgraduate Diploma in Cybersecurity in 2023, designed to prepare students for the complexities of the cybersecurity field.

The program provides an in-depth exploration of cybersecurity, covering various topics, from technological tools to human factors, information management, and organisational processes. It aims to foster a thorough understanding of current and emerging trends, effective practices, legal frameworks, and the latest research in the field. Additionally, the program emphasises developing practical skills necessary for designing and implementing cybersecurity policies and strategies within various organisational contexts. Graduates are expected to possess the capability to undertake significant research in information and cybersecurity, prepared through a pedagogical approach that includes lectures, discussions, case studies, assignments, projects, and extensive research.

The importance of reflection in continuous improvement cannot be understated, especially after the first year of the Postgraduate Diploma in Cybersecurity. Taking time to reflect on the program's implementation allows for a critical assessment of its strengths and weaknesses and provides a structured way to plan for future enhancements. Employing a SWOT Analysis has enabled a comprehensive review of the curriculum, teaching and learning activities, resources, and assessments. This reflective process is pivotal for ensuring the program remains relevant and responsive to new technological trends and the evolving needs of the cybersecurity industry. It reaffirms the university's dedication to delivering an education that meets and exceeds current academic and professional standards.

The following section of the paper offers an overview of the curriculum design principles, focusing on constructive alignment and the experiences from the first year. Section 3, through a SWOT Analysis, examines the program's effectiveness by identifying areas of strength, potential improvements, emerging opportunities, and notable threats. In Section 4, the discussion then moves to strategic recommendations for future development, aiming to enhance the program's impact and ensure it continues to contribute significantly to cybersecurity education.

2. Literature Review

The literature review section of this study delves into two fundamental aspects crucial to the development of educational programs: Curriculum Design and Theoretical Grounding - Constructive Alignment.

2.1. Curriculum design

Designing a high-quality cybersecurity curriculum requires a strategic, methodical approach to curriculum design that aligns with the intricate and dynamic nature of the cybersecurity field and the industry's evolving needs [3]. Curriculum design refers to a systematic approach to structuring course content aimed at facilitating educators in organising instructional sequences [4]. This entails delineating the tasks, assigning responsibility, and scheduling their completion. The overarching aim is to enhance the educational experience, ensuring a coherent alignment between instructional resources and the predefined learning outcomes and objectives [5]. The Nelson Mandela University Cybersecurity Postgraduate Diploma curriculum development process was firmly grounded in the principles of constructive alignment. The following sections will

elaborate on these principles and their practical application to the cybersecurity curriculum.

2.2. Theoretical Grounding - Constructive alignment

Constructive alignment (CA) refers to aligning learning outcomes, teaching and learning activities, as well as assessment tasks to ensure they all support and reinforce each other [6]. The main components of CA [7, 8] are depicted in Figure 1 and defined as follows:

1. **Learning Outcomes (LOs)** are clear statements that specify what students should know, understand, or be able to do by the end of a course or a specific instructional period. They serve as the foundation for the entire teaching and learning process.
2. **Assessment Tasks (ATs)** evaluate whether students have achieved the learning outcomes. Note that all the ATs in combination should allow for assessing all LOs. However, it is not necessarily a one-to-one mapping between LOs and ATs. A single assessment task (AT) can assess multiple learning outcomes, and a learning outcome could be evaluated through various assessment tasks (ATs).
3. **Teaching and Learning Activities (TLAs)** represent all the activities students should engage in to facilitate the development specified by the LOs. This could include lectures, group discussions, practical exercises, field trips, and more. The key is to choose methods that actively engage students and promote deep learning while developing the skills and competencies required for the ATs, which in turn assess the achievement of the LOs.

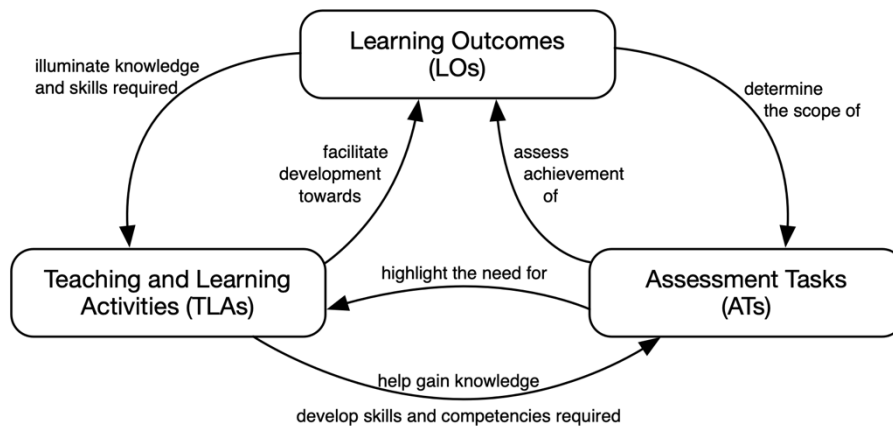


Fig. 1. Components of Constructive Alignment (Adapted from [7, 8])

The arrows indicate the alignment between these components, showing that learning outcomes illuminate the knowledge and skills required and thus determine the scope of the assessment task and as a foundation of the learning activities. Learning activities must support the students in gaining the knowledge and skills to complete the assessment tasks.

In essence, CA ensures that:

- Students are clear about what they are expected to learn.
- The teaching and learning activities support the achievement of the learning outcomes.
- The assessment tasks genuinely assess the extent to which the outcomes have been achieved.

CA posits that when these elements align with one another, students are more likely to participate in in-depth learning, which improves their understanding and retention of the subject matter.

3. The Curriculum Development Process

The Postgraduate Diploma in Cybersecurity was designed with specific Exit Level Outcomes (ELOs) considered most relevant to such a qualification. These ELOs, as presented in Figure 2, describe the knowledge, skills and general competencies a Postgraduate Diploma in Cybersecurity graduate should have on completing the qualification. The initial design of the Postgraduate Diploma in Cybersecurity was done by experienced academic staff in consultation with subject matter experts and industry partners.

To ensure that lecturers understand how their goals fit into the qualification, the ELOs were mapped to specific modules during workshops. Figure 2 shows how this was done to ensure these ELOs were addressed across various modules within the qualification.

The mapping of ELOs to module Learning Outcomes (LOs) helped to ensure that all ELOs are addressed in a balanced way, thereby providing improved alignment in addressing any identified gaps. The initial module learning outcomes (LOs) were created in discussion with subject matter experts during the design of the qualification. These module LOs embody the higher-level knowledge/skill/competence that should be taught through several related topics.

The planning of the various module offerings continued by considering how each of the module LOs would be assessed, which informed the Teaching and Learning Activities (TLAs) and the formative assessment opportunities comprising each of the module offerings. Below are examples of some of the TLAs included:

- Lectures
- Videos Lessons
- Tutorial
- Practical
- Guest lecture
- Reflection
- Group work
- Case Study

The TLA Plan for each module was considered in conjunction with the Assessment Plan, where additional formative feedback opportunities were identified. These additional formative feedback opportunities were then included in the Assessment Planning as deemed relevant.

	Professional Skills in Cybersecurity	Information and Cybersecurity Principles	Technical Aspects in Information and Cybersecurity	Information Security Management	Information Security Governance	Cyber Safety	Research Methodology	Research Report
ELO1	Apply the theory and practice of Information and Cybersecurity in IT in an organisation via a problem-based case study application	F	F	F	S	S	S	F
ELO2	Integrate Culture and Awareness into an Information and Cybersecurity strategy.		F			S		O
ELO3	Conduct a systematic investigation into an Information and Cybersecurity topic				F	F	F	S
ELO4	Examine how Information and Cybersecurity is managed and governed in a provided IT context		F	F	S	S		O
ELO5	Identify and manage the risks of cyber threats by using a range of specialised knowledge, skills, frameworks, technologies, and ethical standards associated with Information and Cybersecurity in a given/provided scenario	F	F	F/S	S	S	S	O*
ELO6	Construct an effective communication/report related to the provided information and cybersecurity context/scenario	F						F

Fig. 2. Mapping ELOs to Modules

Figure 2 legend: o - indicates a focus/selection of project; F - explicitly assessed (formative) but at a lower level than required; S - explicitly assessed at exit level (summative).

4. Methodology

This study employed a Critical Reflection Methodology to analyse the inaugural year of the Postgraduate Diploma in Cybersecurity at Nelson Mandela University. Critical Reflection is a systematic and rigorous process that examines assumptions, values, and beliefs underlying actions, experiences, and outcomes, facilitating deeper understanding and informed decision-making [9].

The research methodology encompassed three main steps, namely: data collection, data analysis and critical reflection as discussed in the following sub-sections:

4.1. Data Collection

Data for this study was collected through the lived experiences of curriculum developers, lecturers of the modules, and program documentation. These sources provided a comprehensive understanding of the program's implementation and its impact. Data for this study was collected through a series of structured review work sessions with all lecturers of the modules, conducted at the end of each academic semester. These sessions were designed to facilitate a comprehensive reflection on the implementation and impact of the program through a SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis framework.

Review Work Sessions.

At the end of each semester, all lecturers participated in structured review work sessions. These sessions were organized to gather detailed insights into the program's performance and areas for improvement. Each session lasted approximately two hours and was facilitated by a senior curriculum developer to ensure consistency and depth in the discussions.

SWOT Analysis.

During these sessions, lecturers reflected on the Strengths, Weaknesses, Opportunities, and Threats (SWOT) related to their modules. The SWOT analysis provided a structured method for lecturers to critically assess various aspects of the program. For example:

- Strengths: Lecturers identified effective teaching strategies, successful student engagement activities, and modules that received positive feedback.
- Weaknesses: Areas where students struggled, gaps in the curriculum, and any logistical issues were discussed.
- Opportunities: Potential improvements, integration of new technologies, and opportunities for collaboration with industry partners were explored.
- Threats: Challenges such as emerging cybersecurity threats, resource constraints, and external factors impacting the program were identified.

Documentation and Analysis.

The reflections and insights gathered from these sessions were meticulously documented. Detailed notes were taken during the discussions, and these were later transcribed and categorized according to the SWOT framework. This qualitative data was then analysed to identify recurring themes and patterns that provided a comprehensive understanding of the program's implementation and its impact.

4.2. Data Analysis

The qualitative data collected was analysed thematically to identify recurring patterns, themes, and insights. The themes emerged through an inductive coding and categorisation process guided by the overarching objectives of the study. It was then further analysed using the SWOT Analysis Framework [10]. This reflective analysis was structured around the SWOT (Strengths, Weaknesses, Opportunities, and Threats) framework. This framework systematically examines internal and external factors influencing the program's performance and sustainability. Strengths and weaknesses focus on internal attributes, such as curriculum design, teaching methodologies, and resources, while opportunities and threats consider external factors, including market trends, industry demands, and technological advancements.

4.3. Critical Reflection Process

The critical reflection process involved iterative cycles of results interpretation and sensemaking [11]. Researchers engaged in reflexive dialog to challenge assumptions, interrogate biases, and uncover underlying tensions within the program. This process gave a better understanding of complex issues and facilitated the identification of potential areas for improvement and innovation.

While acknowledging that the data was primarily obtained from curriculum developers and lecturers, who are also the paper's authors, there is potential for inherent biases in the collected data. The perspectives shared by the authors could easily just reflect their own experiences, perceptions, and interests within the program, which could influence the analysis and interpretation of findings. However, a reflexive and critical approach was adopted to minimise these biases and enhance the credibility of the study's findings. Reflexivity allows us to continuously reflect upon and critically assess our biases, assumptions, and influences on the research process, from design to data interpretation, fostering an environment of transparency and objectivity. Complementarily, Critical Engagement propelled us to rigorously challenge our data interpretations, question underlying assumptions, and explore diverse perspectives, thereby ensuring a more comprehensive analysis.

5. Results

As we navigated through the inaugural year of the Postgraduate Diploma, it became paramount to pause, reflect, and discern the pathways toward continuous improvement. In this section, we delve into the insights gleaned from our experiences as curriculum developers and lecturers during the inaugural year offering of the Postgraduate Diploma. Through introspection and analysis, we uncover the successes, challenges, and lessons learnt that have shaped our journey thus far. These reflections serve as a retrospective examination and a springboard for refining our approach, enhancing our practices, and ultimately propelling us towards pursuing excellence in education.

5.1. Reflections from the Curriculum Development Perspective

Looking back on the first year of the Postgraduate Diploma, our role as curriculum developers has given us plenty to think about. We were responsible for shaping the program's structure and content to ensure it met its educational goals. Overall, we were pleased to see how well the program's modules have encouraged students to think critically and discuss different subjects. But we've also noticed some areas where things could be improved.

For example, we noted that some parts of the program could be updated to keep up with changes in industry and technology. We realised that it is important for the program to be flexible enough to meet the needs of different students. This means being open to making changes based on feedback and finding new ways to support students as they learn. Our reflections on these issues have shown us that there is always room for improvement, and we are committed to ensuring the Postgraduate Diploma continues to be the best it can be.

5.2. Reflections from the Lecturing Perspective

Being lecturers in the Postgraduate Diploma program has been a rewarding experience, but it also had challenges. Our duty is not just to teach students about different topics but also to help them learn how to think critically and work together. We had valuable discussions throughout the first year and seen students engage with the material. However, we have also had to find ways to balance teaching with creating a supportive learning environment.

This has sometimes meant trying out new teaching methods and finding ways to help students who might be struggling. We have learned that being open to feedback and

willing to adapt our approach is key to being effective teachers. Our reflections on our teaching practices have shown us that there is always more to learn, and we're committed to improving as educators.

Reflecting on the first year of the Postgraduate Diploma from both the perspective of curriculum developers and lecturers has assisted us in identifying the strengths, weaknesses, opportunities, and threats as discussed in the next section.

5.3. Post-delivery SWOT analysis

This section presents a comprehensive post-delivery SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis, focusing on critical components of our program: the Module Development Process, Study Resources, Covering Learning Outcomes, and assessment tasks. This analysis aims to shed light on our experiences, challenges encountered, and strategies to overcome them. It also seeks to identify areas for continuous improvement and innovation as we strive to adapt and enhance the curriculum and its delivery mechanisms.

Module Development Process.

The Module Development Process is the foundation for the Postgraduate Diploma in Cybersecurity. This process encompasses the conception, design, development, and implementation of each module, aiming to ensure that the curriculum meets academic standards and addresses the practical demands of the cybersecurity field. The development process is critical, directly impacting the program's relevance, quality, and effectiveness. In evaluating this process through a SWOT analysis, we will explore the strengths that contributed to robust module creation, identify the weaknesses that may have limited module effectiveness, recognise the opportunities for enhancement, and acknowledge the threats posed by external factors such as technological advancements and changing industry needs.

Table 1. SWOT analysis of the module development process

Strengths	Weaknesses
<ul style="list-style-type: none"> • A Constructive Alignment (CA) approach was used throughout the module development to align learning outcomes, teaching and learning activities, and assessment tasks. This ensures a consistent and quality-driven approach. • Engagement with subject matter experts and industry partners in the initial design phase guaranteed the relevance and practical applicability of the curriculum. • Module developers were subject matter experts in the relevant offerings. 	<ul style="list-style-type: none"> • The need for alignment and coordination necessitates collaborative engagements which in turn delay the implementation process when some members were unavailable.
Opportunities	Threats
<ul style="list-style-type: none"> • Continuous improvement through feedback mechanisms could enhance the program's adaptability to changing cybersecurity landscapes. 	<ul style="list-style-type: none"> • Rapidly evolving cybersecurity threats may necessitate frequent updates to the curriculum, posing a challenge to maintaining up-to-date content.

Content and Learning Resources.

Study Resources are pivotal in enriching the learning experience, providing students with the tools, materials, and support needed to grasp complex concepts and apply them in real-world scenarios. These resources range from textbooks and research papers to online labs and simulation tools. A comprehensive SWOT analysis of the study resources will illuminate the strengths that facilitated effective learning, pinpoint the weaknesses in resource provision and accessibility, uncover opportunities for leveraging new educational technologies, and highlight threats such as the rapid obsolescence of information and tools in the fast-evolving cybersecurity landscape.

Table 2. SWOT Analysis of the Content and Learning Resources

Strengths	Weaknesses
<ul style="list-style-type: none"> • Systematic identification of study resources through consultation with subject matter experts ensures the selection of high-quality, relevant materials. • Utilisation of platforms like Perlego for accessible and affordable resources enhances student engagement and learning. 	<ul style="list-style-type: none"> • Dependence on specific platforms for resources might limit exposure to a wider range of materials or newer publications not available on those platforms.
Opportunities	Threats
<ul style="list-style-type: none"> • Expanding resource bases to include open-source materials and the latest research publications could provide students with a broader learning perspective. 	<ul style="list-style-type: none"> • The dynamic nature of cybersecurity might lead to quickly outdated resources, requiring continuous review and updated processes.

Covering Learning Outcomes.

Covering Learning Outcomes effectively is essential for the educational integrity and success of the Postgraduate Diploma in Cybersecurity. Learning outcomes define the knowledge, skills, and competencies students are expected to acquire upon completing the program. They serve as a roadmap for instructors and students, guiding the teaching methodology and learning process. This section dissects the alignment between the content and learning resources, assessment tasks and the intended learning outcomes. The SWOT analysis will delve into the strengths of our outcomes-based approach, the weaknesses where improvements are necessary, the opportunities for enhancing outcome coverage, and the potential threats to achieving desired educational objectives.

Table 3. SWOT analysis of the learning outcomes

Strengths	Weaknesses
<ul style="list-style-type: none"> • The program covers a comprehensive range of LOs, from theoretical knowledge to practical application, ensuring well-rounded education in cybersecurity. • The alignment of LOs with industry standards and current practices increases graduates' employability and readiness to tackle real-world challenges. 	<ul style="list-style-type: none"> • The broad scope of LOs might dilute the focus on developing specialised skills in specific areas of cybersecurity.
Opportunities	Threats
<ul style="list-style-type: none"> • Continuous engagement with industry and alumni can help refine LOs to meet emerging cybersecurity challenges and employer expectations. 	<ul style="list-style-type: none"> • Rapid technological advancements and changing cybersecurity landscapes may require frequent updates to LOs, challenging the program's stability and continuity.

Assessments Tasks.

Assessments are crucial for measuring student progress, understanding, and mastery of the subject matter. They play a significant role in motivating students, shaping their learning experiences, and determining their final qualifications. This program component is subject to scrutiny regarding its ability to accurately and fairly reflect the student's knowledge and skills. Through a SWOT analysis, we will assess the strengths of our current assessment strategies and their alignment with learning outcomes, identify any weaknesses in our approach to evaluation and feedback, explore opportunities for innovation in assessments, and consider threats that could compromise the assessment's effectiveness and fairness, such as biases or the rapid advancement of technology altering skill requirements.

Table 4. SWOT analysis of the assessment tasks

Strengths	Weaknesses
<ul style="list-style-type: none"> • A variety of assessment tasks, including tests, quizzes, group portfolios, and assignments, cater to different learning styles and ensure a comprehensive evaluation of student competencies. • The diversity in assessment types encourages a broader skill set development, including teamwork, critical thinking, and practical problem-solving. 	<ul style="list-style-type: none"> • The complexity of coordinating multiple assessment types could potentially impact the consistency and fairness of the grading process.
Opportunities	Threats
<ul style="list-style-type: none"> • 	<ul style="list-style-type: none"> • Balancing the weightings of various assessments to accurately reflect the importance of each learning outcome can be challenging, especially in a rapidly evolving field like cybersecurity.

Continuous improvement efforts and engagement with industry trends and feedback are crucial for addressing the identified weaknesses and threats while capitalising on the strengths and opportunities.

6. Discussion and Recommendations

As we move forward with the Postgraduate Diploma in Cybersecurity, leveraging the insights gleaned from our SWOT analysis to bolster program effectiveness and relevance is imperative. As educational institutions globally strive to develop and refine cybersecurity programs, our experience with the inaugural year of the Postgraduate Diploma in Cybersecurity provides valuable insights that can inform similar endeavours. While the recommendations presented here have been instrumental in our continuous improvement efforts, they are also highly applicable to institutions seeking to create or refine a similar offering. Here are the key recommendations that seek to address the current gaps and leverage growth opportunities, ensuring that graduates are well-equipped for the complexities of cybersecurity.

Embracing Agility and Flexibility

Building on the lessons learned, we emphasise embracing agile methodologies in our curriculum development process. This approach will expedite implementation and ensure the curriculum's alignment with the dynamic cybersecurity landscape. The experience of needing to adjust the teaching timetable for 2024 to accommodate an additional week for assessments exemplifies the necessity of an adaptable framework that can quickly respond to feedback and changing requirements.

Strengthening Industry Collaboration

Our future strategy includes fostering stronger collaboration with industry stakeholders and subject matter experts. This partnership will enrich the curriculum with practical insights and enhance its relevance to the current job market. Regular engagement with industry professionals will keep the curriculum up-to-date and ensure it meets employers' expectations, thus improving our students' career readiness.

Diversifying Resources

Expanding our resource base to include open-source materials and the latest research publications will give students a wider range of knowledge and perspectives. This diversification will enrich the learning experience and ensure that our students are well-prepared to address contemporary challenges in cybersecurity.

Implementing Continuous Feedback Mechanisms

Establishing robust feedback channels from students, faculty, and industry partners will facilitate the iterative refinement of our curriculum. This continuous feedback loop will enhance the program's adaptability and responsiveness, ensuring it evolves in line with educational and industry developments.

Enhancing Assessment Coordination

A critical focus will be streamlining assessment coordination to ensure consistency, fairness, and alignment with learning outcomes. Incorporating feedback mechanisms

into the assessment processes will offer insights into the curriculum's effectiveness and highlight areas for improvement.

Adjusting Teaching Timetables Based on Feedback

As demonstrated by the need to extend the time allocated for assessments, adjusting teaching timetables based on student feedback is crucial for ensuring that all learning objectives are met comprehensively. The teaching timetable for 2024 will be adjusted to reflect these insights, showcasing our commitment to a student-centred learning approach.

7. Conclusions

In concluding our exploration into the inaugural year of the Postgraduate Diploma in Cybersecurity, it becomes evident that the deliberate application of constructive alignment has profoundly shaped our curriculum's development and delivery. By aligning learning outcomes with teaching and learning activities, as well as assessment strategies, we have created a coherent and focused program that adheres to academic standards and is deeply relevant to the practical demands of the cybersecurity field.

The journey through the first year of this program highlighted the importance of continuous improvement and adaptation. The insights gained from a SWOT analysis, combined with our commitment to enhancing the program through various strategic approaches, underscore the dynamic nature of cybersecurity education. It is a field that demands not just technical expertise but a comprehensive educational strategy that includes ethical considerations, legal knowledge, soft skills, and a global perspective.

Our experience, characterised by challenges and achievements, offers valuable lessons for our institution and guides others embarking on similar endeavours. The principle of constructive alignment has proven to be a cornerstone of effective curriculum development, ensuring that our program remains responsive to the evolving landscape of cybersecurity and the needs of our students.

As we move forward, we will focus on refining our curriculum, fostering industry collaboration, expanding our resource base, and integrating feedback mechanisms. These efforts, grounded in the theory of constructive alignment, will continue to drive our program towards excellence, preparing graduates who are technically proficient, ethically informed, and professionally adaptable.

The inaugural year of the Postgraduate Diploma in Cybersecurity has been a foundational step in a continuing journey of educational innovation and excellence. By adhering to the principles of constructive alignment and embracing a holistic approach to program development, we are poised to make significant contributions to cybersecurity education, ultimately equipping students with the skills and knowledge necessary to thrive in an increasingly complex digital world.

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Empowering Business Students for the Fourth Industrial Revolution: A Hands-On Pedagogical Approach

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Abstract. The Fourth Industrial Revolution (4IR) has brought about significant changes in business and society. Introducing a new pedagogical approach for Commerce students to meet future workplace demands. This study looks at an approach that emphasises training students on technologies beyond their regular curriculum, such as artificial intelligence, blockchain, 3D printing, and virtual reality. By providing practical encounters with these technologies, students gain a tangible experience and a deeper understanding of their value and need. We administered a survey to measure the approach and gain an understanding of the student's preferences and experience with these technologies. The results revealed a shift in student engagement and learning preferences, with most expressing enthusiasm for experiential learning methods. Among the various technologies, ChatGPT, 3D printing and 3D modelling were the most enjoyable and practical, indicating the benefits of integrating such applications into the curriculum. The study concludes by emphasising the importance of integrating theory with hands-on experiences to gain a deeper understanding and prepare students for the challenges of the 4IR era. The study also recommends early planning and continued adaptation for optimal results. By implementing this approach, students can develop the necessary skills to meet the evolving demands of the digital economy.

Keywords: Fourth Industrial Revolution, Pedagogical Approach, Business Education, Experiential Learning, Emerging Technologies.

1. Introduction

“If we teach today’s students, as we taught yesterday’s, we rob them of tomorrow” - John Dewey (1915).

The wave of the Fourth Industrial Revolution (4IR) is reshaping society. Different sectors are undergoing disruptive changes due to the emergence of innovative technologies, including artificial intelligence (AI), cloud computing, robotics, 5G networks, 3D printing, and blockchains [1, 2]. 4IR technologies are making it possible to blend the physical world with the digital world in what is often referred to as cyber-physical systems [2-4]. A consequence of the 4IR revolution is that industries are demanding graduates who possess not only their subject-matter expertise but also the

skills to apply and use emerging 4IR technologies to solve complex problems in the workplace [1]. To be employable, graduates need to possess a variety of soft and digital skill sets, including creativity, problem-solving, the ability to work in a team, social, and emotional skills [2, 5]. Higher education institutions (HEIs) must equip students with the digital skill sets they need to participate meaningfully in the digital economy [6, 7].

The context for the study reported in this paper is an undergraduate first-year service module that exposes students to fundamental information technology/systems concepts. The outcomes of this module state that students should be able to demonstrate the following:

- an understanding of the design thinking process and its application to solve a given problem.
- an awareness of the main areas of information systems in organisations.
- an understanding of hardware, software, data, computer networks and pervasive
- computing technologies to manage the implementation thereof in an organization.
- an understanding of the different types of information systems in relation to their implementation in an organisation.
- the ability to describe the systems analysis, design, and implementation process, as well as user experience of information systems.
- awareness and understanding of the positive and negative impacts of social media on organisations.
- an ability to take account of security, privacy and ethical issues in information systems.

The module is presented to students enrolled in the BCom (Informatics), BIT (Information Systems), BCom Accounting Sciences, Economic and Management Sciences, Financial Management Sciences, Investment Management, and Supply Chain Management degrees (which we collectively refer to as Commerce degrees). However, around 80% of the 1,340 students enrolled in EMS are Commerce students. Most of these students have a limited IT background.

A constant challenge for lecturers in the module over the years is the lack of enthusiasm particularly by the BCom Financial Sciences and BCom Accounting students, who do not see the relevance of an information systems module in their degree and future career. At the same time, recent studies have shown that accounting practitioners expect accounting graduates to also possess digital and IT skills to ensure their employability [3, 5].

Another major problem with this module is the low rate of class attendance, primarily because many students felt they could read up on these IT concepts themselves. As part of the students' feedback during the 2022 academic year, many students stated that although they were taught all these new technologies, some of them had never seen what they looked like in real life, and thus, they struggled to understand the concepts.

To address the gap between theory and practical application, as well as the lack of enthusiasm by students, in 2023, we incorporated practical applications of 4IR technologies in the classroom, in addition to teaching theoretical concepts. This allowed us to link the theoretical concepts covered in the module to the type of skills and knowledge that future employers would require students to possess. The module was adapted to incorporate a multifaceted teaching approach, integrating various 4IR domains, including artificial intelligence, Blockchain, 3D printing, and Virtual reality. These domains were not just taught in theory but were brought to life in the virtual world and in the physical classroom space, demonstrating their real-world application and relevance to the students' future careers.

The students had practical encounters with these 4IR technologies built into the curriculum, giving them a hands-on experience of what they could expect in the future workplace. For example, students designed their idea of blockchain digitally as part of a pre-class activity, thereby taking them to a digital world. This was a pre-class activity, and students were expected to create a 3D design model (visualisation) of how they visualise a blockchain to look, after which they had to upload their designs as a .stl file. In the classroom, we discussed the design of students' 3D blockchain models and then used a 3D printer to print physical objects created at the University's Centre for the Future of Work (we were unable to print students-designed blockchains due to the time constraint in the physical lecture). The objects printed in the classroom included finger rings, an octopus, and an axolotl, linking to the physical world.

Afterwards, students reconnected to the digital world by introducing virtual reality, metaverse, and digital scanning.

The assessment of the classroom content happened in two stages. Firstly, students were asked to complete a generative AI assignment based using ChatGPT during the semester. This assignment aimed to develop students' understanding of AI and its applications in various industries. Secondly, during the final online examination incorporated questions based on the content and activities discussed during the disruptive technology classes.

2. Literature review

2.1. Teaching approaches

Businesses are realizing that information systems form potent drivers of innovation for their enterprises. It enables the creation of technology-oriented solutions for new business problems. Therefore, companies must keep the IS discipline relevant during significant advances in intelligent machines. Academics worldwide recognise that their curricula should increasingly reflect an analytical and digital emphasis to ensure that universities remain value creators for their students and alumni. The Management Curriculum for the Digital Era (MaCuDE) is a collaborative effort among academics of more than 100 business schools globally. Its goal is to recommend changes to business curricula based on the influence of digital technologies on business transformation. This aligns with curriculum development conducted by the Association for Information Systems (AIS) and the Association for Computing Machinery (ACM). It summarizes the core digital topics and tools used by a sample of global IS departments [7].

Universities employ various teaching approaches to cater to different subjects, learning styles, and educational philosophies, including lecture-based teaching, collaborative learning, problem-based learning, case-based learning, and technology-enhanced learning. These approaches are often combined or adapted to suit the needs of courses, disciplines, and student populations. Penprase [8] recommends basing any education plan for the 4IR on the Third Industrial Revolution's development of in-person instruction and diverse educational resources.

In recent years, there has been a surge in the application of technology in education, which affords educational establishments a range of opportunities to embrace new types of learning. [9]. Rübmann and Lorenz [10] state that adequate knowledge of the various 4IR components forms the basis of understanding the role and relevance of 4IR in the growth and development of teaching and learning in HEIs. The 4IR presents many exciting opportunities to HEIs. Staff and students from various faculties in HEIs should learn about the elements necessary to implement the 4IR successfully. Understanding these components will facilitate effective teaching and learning [11].

Despite this widespread advocacy, many universities struggle to keep pace with industry standards [12], and their management information systems (MIS) curricula are not aligned with the industry's needs. Innovative pedagogy in the MIS curriculum is recommended to prepare students for industry and keep pace with changing industry needs [12]. A recent study on the impact of active learning methods on the academic performance of first-year management students shows that active teaching methods have a positive effect on academic performance [13].

Active teaching methods are instructional strategies that engage students in learning through active participation rather than passively receiving information. These methods often involve student activities such as discussions, problem-solving, group work, hands-on experiments, simulations, and other interactive exercises. Experiential teaching encourages deeper understanding, critical thinking, and retention of information by actively involving students in the learning process, thus promoting interaction and engagement. Experientially taught students may also engage in higher-order thinking, such as analysis, synthesis, and evaluation [14].

2.2. The fourth industrial revolution (4IR)

Due to the rapid technological changes over the past few years, one must realize that as educators, we must introduce and start teaching some of the new-generation technologies stemming from the Fourth Industrial Revolution (4IR) [15]. One must recognise the reshaping of business strategies, changes in academic and pedagogical approaches, how people socially interact, and the impact on future careers and work [16-18]. It is noted that 40% of the current job market must be reskilled by 2025 [19].

Kruger and Steyn [15] caution that failing to adapt to these rapid changes and new technologies could have adverse effects on various sectors, including the labour market, policymakers, and even lead to labour disruptions [20], as exemplified by automation [21]. However, it is crucial to recognize that these technologies also bring numerous opportunities. Universities have the potential to play a significant role in preparing and reshaping the future workforce to leverage these technologies [15]. This positive perspective can help to motivate educators to embrace these changes and adapt their teaching methods and curriculums accordingly.

As the World Economic Forum's Report on the Future of Jobs highlights, the third- and fourth-ranked occupations experiencing reduced demand are roles in accounting, bookkeeping, and payroll clerks (ranked third), as well as positions in accountancy and auditing (ranked fourth) [22]. This underscores the need for adaptation as even traditional fields of commerce are already facing challenges [23]. Studies by Elo and Pätäri [24] and Maelah and Aman [25] further suggest that digitisation and globalisation are driving significant changes in the accounting profession. This implies that the nature of work within this field will change significantly in the coming years. The increased demand for soft skills and the rapidly changing technology based on 4IR is creating heightened pressure on HEIs to integrate these skills into current curriculums [26]. This stark reality should motivate educators to start exposing students to various technologies, enabling them to understand the types of technologies available and their potential impact on future work.

Consequently, we wanted to expose the students to these technologies by incorporating this new teaching approach by keeping the following objectives in mind: 1.) To facilitate students' comprehension of new technologies and the potential disruptions they bring, particularly in 3D printing and 3D modelling; 2.) To create a visual experience for students by blending the virtual and physical worlds to develop an understanding of the difference and the interaction between these two worlds. 3.) To create awareness among students of the impact and the possibilities of using these types of technologies in the business world.

3. Methodology

This study follows an exploratory quantitative approach. As this was a completely new way of teaching and exploring different teaching techniques, the researchers wanted to investigate the extent to which students felt this type of approach worked for them or could work in the future. Although some of these activities were linked to certain assessment activities, our focus was on the experience the students had with this different teaching approach, therefore students had to complete a survey based on their experience with the different teaching styles and technologies. Upon the conclusion of the course, students were invited to participate in a survey.

Despite a response rate of just over 10%, with 147 students providing feedback, the results have been instrumental. While we had hoped for a higher-class attendance with the implementation of our new teaching approach, this was not the case. However, the feedback we received has been invaluable in guiding our future teaching strategies. It has also provided us with unique insights into how we can introduce commerce students to 4IR technologies, a topic they may not encounter in other modules. As this is an exploratory study, describing and providing examples of the teaching interventions is essential.

As discussed in the introduction section, students received an assignment to create a 3D Design-model (visualisation) of how they visualise a Blockchain to look. The concept of Blockchain was a self-study pre-activity. Students then had to upload a .stl file which was assessed. Figure 1 is an example of a static view of a student's submissions, the models could be rotated to view the links.

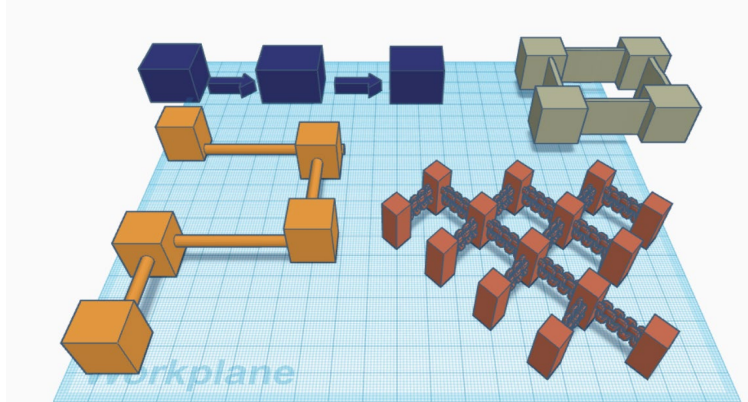


Fig. 1. Blockchain examples

The digital world was brought into the physical world by getting an actual 3D printer into the classroom (Figure 2). The printer printed 3D objects during the lecture, and students could see how it works and what a 3D printer is. After class, students engaged with the lecturers.



Fig. 2. 3D Printer in class

To demonstrate the integration of the physical and digital worlds, one of the lead authors was 3D scanned and placed in a virtual world (Figure 3). This virtual world was introduced during class, followed by an introduction to the Metaverse. In this lecture, we introduced VR headsets and the Metaverse, demonstrating to students the potential of this virtual world in a business environment.



Fig. 3. Virtual world

After these activities, the students completed the survey analysed in the following section.

4. Data analysis and findings

Out of all the responses we received, 81.1% belong to students pursuing degrees in Accounting Sciences (31%), Financial Sciences (22.46%). To determine the students' preferred learning methods, we asked them how they learn best. 60% of the students either strongly agreed or agreed with the statement that they learn best by reading the notes provided. These notes are given to students every week after each lecture on their LMS, Clickup. It is, therefore, not surprising that the second highest score was given for using Clickup extensively, followed by watching YouTube videos.

During the pervasive computing lectures, students were introduced to various Fourth Industrial Revolution (4IR) technologies. They were asked to choose the most enjoyable activity from a list of options. According to Figure 4, the students enjoyed CHATGPT the most, followed by 3D printing and 3D modelling.

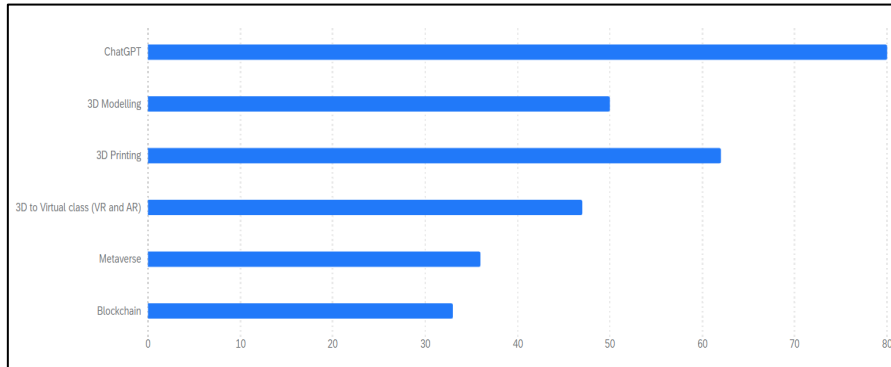


Fig. 4. Most enjoyable activity

When asked which technologies they encountered for the first time in the INF 112 class, blockchain and the Metaverse were selected the most. Only 5% of the students indicated this was their first encounter with ChatGPT.

When asked which of these technologies they would use again for their studies, it is clear from Figure 5, that this is ChatGPT. As educators, we need to take note of this, as our students are using AI, whether we agree or like it or not.

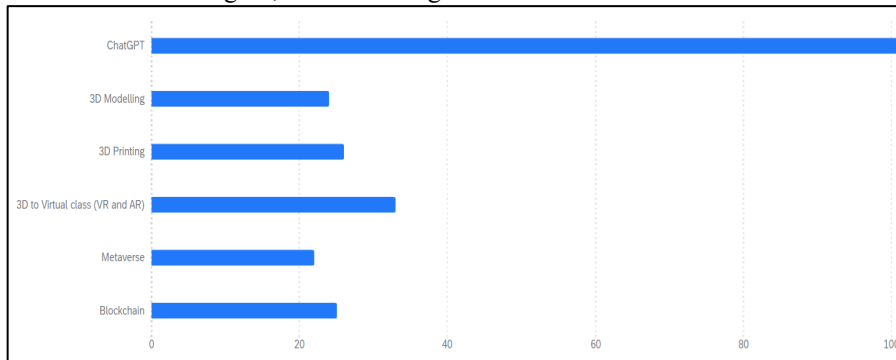


Fig. 5. Technologies to use again

We then asked students to qualitatively state which technology they would use in future and for what purpose. Most students indicated that they would use ChatGPT extensively in the future, with some quotes verbatim:

- “ChatGpt to improve emails and help with research”
- “ChatGPT for quick research in both my personal life and working environment.”
- “ChatGPT - Gain Basic understanding and use it as a guidance tool.”
- “I will be using chatGPT to check if my grammar is orrect.”
- “Using ChatGPT I get resources from it such as codes for javascript and html. Creating Websites is much easier using both knowledge and AI”

Many students also indicated how they will use the 3D printer or 3D modelling:

- “3D print concepts to visually study them”
- “3D Printing and 3D designing because they are cost effective and produce rapid prototyping.”
- “I would like to use 3d printing to create tangible three-dimensional objects for myself”
- “3D printing when I want to view my future home or business space”
- “3D modelling can be used to solve complex problems.”
- “Allowing students to make some sort of a 3d printing group project”

There was however, one quote from a student that stood out: “I am not considering using it again as I personally believe using ChatGPT makes you a lazy student.” This makes one realise that although there is hype around 4IR technologies, some students and perhaps academics still feel that these technologies could be dangerous and even make us lazy, as stated by the student.

5. Key takeaways

From the student's perspective, intertwining theory with hands-on experiences, allowed students to gain a deeper understanding of 4IR's core principles and their real-world implications. This approach introduced students to what they can expect at university and in their profession and excites them about the future possibilities.

From an educator's point of view, this approach requires proper planning, long hours, and time to create all the activities and assignments, so that they link together. One has to start early in the semester or academic year to be able to implement this. Fortunately, we had our institution's makerspace who assisted us in creating the digital artifacts and 3D printing.

6. Conclusions and Future Research

Commerce students are increasingly expected to demonstrate a working knowledge of 4IR technologies when they enter the industry, placing great demands on universities to combine theoretical concepts with real-life experiences. This study describes how an introductory course in Business Information Systems succeeded in introducing first-year Commerce students to pervasive technologies. Most students reported being amazed at the physical use of technologies such as 3D printing, which most had only heard of before.

ChatGPT was the technology that held them spellbound. It is an example of pervasive technology that is accessible and easy to use, and the students see its benefits. However, there is also a risk involved that we as educators need to teach them about. The students, driven by their curiosity and eagerness, expressed their determination to continue using these technologies, even if they were not yet fully comprehending their functionalities.

Incorporating physical examples of technologies described in university textbooks is not a trivial task, and lecturers alone cannot accomplish it. The successful integration of physical examples of technologies into the curriculum is a collective effort, requiring the collaboration of various role-players in the institution. However, the impact of this collaboration is significant, as it paves the way for a more engaging learning experience. Future research in this module envisages incorporating a greater degree of active learning in the classroom to stimulate interest and encourage students' engagement.

7. Acknowledgements

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Interactive E-learning Tool for an ERP module using Sage Evolution

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Abstract. Universities are adopting and adapting technology more than ever to meet online learning and teaching demands. Unfortunately, some of the technologies are frequently costly and difficult to tailor to the needs of students. The purpose of this paper is to present the design of an Interactive E-learning tool that provides third-year ERP students at Nelson Mandela University access to a quick overview of complex ERP systems and related concepts. The tool can be a proof-of-concept for universities to adopt in-house developed learning tools that extend their existing learning management system, thereby addressing the cost concern. The design science research (DSR) methodology was used in the design process of the ERP Interactive E-learning tool. Furthermore, the development of the ERP Interactive E-learning Tool used an iterative process and was developed using H5P and Moodle. Lecturers can easily develop affordable interactive e-learning tools tailored to the needs of their students with the extension of their existing learning management systems. The Interactive E-Learning Tool can enrich the learning of complex modules at a lower cost.

Keywords: ERP, interactive e-learning, online learning, H5P, Moodle, learning management system integration.

1. Introduction

The Covid-19 pandemic accelerated the adoption of online learning by universities globally. While online learning had slowly gained traction before the pandemic, the need for social distancing forced the migration to online learning as a crisis response [1]. Online learning, sometimes referred to as electronic learning (e-learning) is the use of information and communication technologies (ICT) which include the internet, digital media and television to support and design the learning process, transfer knowledge and provide distance learning and teaching [2].

One of the most common e-learning tools universities implement is the learning management system (LMS) [3]. LMS is software that supports lecturers in managing lectures and courses, monitoring and evaluating students, grading assessments and many other administrative tasks [2] an example of such software is the Moodle platform which is an open-source platform with adaptable features to support learning and teaching. One such feature is the Hypertext Markup Language 5 Package (H5P) plugin based on the JavaScript framework that enables the creation of interactive content such as videos that can be shared and reused [4]. Interactive videos are a crucial form of learning tool in an e-learning system because they allow learners to engage with

learning information while viewing the video [5]. Interactive videos aim to provide students with an engaging learning environment to retain and recall information better [6].

Interactive videos can be used to create simulations which are valuable in learning complex modules like Enterprise Resource Planning (ERP). ERP systems have grown increasingly significant in business operations. These systems aid businesses by exchanging and sending information and data across all functional units both internal and external to the organisation [7]. Therefore, it has become critical to educate students in tertiary education about these systems [8].

ERP systems provide a list of modules. However, the most common modules used in industry include accounting or financial management, inventory management, marketing management, customer relationship management (CRM), and human resources (HR) [9]. Due to the complexity and comprehensiveness of these modules, full training courses for these industry-specific modules are not viable at the university level. However, due to the growing importance of ERP systems in business operations, it is essential to educate students in higher education about ERP systems. Teaching business functions and equipping students with the technical skills needed for industry will bridge the gap between university graduates and industry ERP positions. ERP simulations can provide students with a learning environment to experience ERP systems, resulting in higher engagement levels, skill levels, motivation, and positive behavioural changes [10].

The use of the H5P Moodle plugin presents an opportunity for universities to create such simulations to enhance the quality of ERP modules and engage students in their learning. The purpose of this paper is to present the design of an interactive e-learning tool for a third-year ERP module at Nelson Mandela University (NMU) that gives them access to a quick overview of complex ERP systems. The tool should provide a substitute for pre-existing training courses that are frequently costly and difficult to tailor to the needs of students.

The paper is structured as follows: The next section presents a literature review that delves into the concepts of e-learning, the H5P framework, ERP systems and a review of existing ERP learning tools. The research methodology is presented next, followed by a description of the development and evaluation of the proposed interactive tool. The final section presents concluding thoughts and further research opportunities.

2. Literature Review

This section presents a review of existing literature to provide context to the research study. Section 2.1 discusses the concept of e-learning and the advantages and challenges it presents. Section 2.2 delves into a discussion on the characteristics of interactive e-learning tools and H5P as a plugin for designing interactive content for e-learning. This is followed by Section 2.3 which addresses ERP systems and their complexities. Section 2.4 presents a review of ERP learning platforms.

2.1. E-Learning

Many universities hesitated to adopt e-learning due to difficulties in integrating these technologies to support teaching and learning [2]. The Covid-19 pandemic was a

global-scale challenge to universities due to the need for social distancing, which required a shift in the modes of learning and teaching. E-learning became the response to this challenge. Universities rapidly pivoted to technological tools to keep learning and teaching going.

E-learning is a learning strategy that uses communication technologies and information to engage students in learning regardless of time or place [11]. Some of the advantages of e-learning include improving communication and collaboration with students, increased flexibility and engagement and better understanding of lectures [2]. Opposing opinions on e-learning contest that e-learning does not have the same value as face-to-face learning [2]. Access to technology, technology proficiency, technology cost and adversity to change are some e-learning challenges cited [1, 2].

To successfully support learning, e-learning requires interactive multimedia technology that supports computer, video, and audio technology to appropriately integrate and boost engagement [11]. A keystone of many e-learning courses has been digital videos, which take two forms – linear and interactive [6]. A linear video is where viewers watch the video from beginning to end in a straight line, with no breaks or interactions with the material [6]. This results in ineffective learning with the learning content only retained for a short period. In comparison, an interactive video includes aspects such as clicking to explore, answering questions, clicking hot spots, or answering surveys and voting [6] which encourage students to interact with the presented activity and its content. The interactive video works by breaking down complex ideas into small, understandable chunks, allowing the learner to process information quickly [6].

2.2. Interactive E-learning Tools

[12] provides a set of characteristics that are essential for interactive e-learning tools to be engaging. These characteristics are real-life scenarios, graphics, real-life tools, interactivity, assessments, and evaluations.

Interactive e-learning tools require real-life scenarios that reflect challenges that students would face if they were doing the task in a real-life situation [12]. Users of the interactive e-learning tool should be able to relate to the characters or roles completing the scenario tasks and perform these tasks with real-life tools.

To ensure the e-learning tool is immersive; graphics and other media formats should be incorporated [12]. Such as videos and sounds that would induce a character's emotions or role in completing a task in a real-life environment. Further, the e-learning tool should have interactivity, including complex drag-and-drop tasks, multimedia, animated videos, or customised audio [13].

Finally, assessments and evaluations should be incorporated into the interactive e-learning tool [12]. Assessments and evaluations provide students with a way to keep track of their progress and lecturers with metrics to evaluate how well students are coping with the course content.

To design the proposed interactive e-learning tool, these characteristics are fundamental requirements. Interactivity and its identified characteristics are supported by the H5P which is a plugin that can be integrated into most LMS such as Moodle, Canvas, Brightspace, and Blackboard. H5P may be configured to display interactive content on LMS sites and can be adapted to the specifics of each lecturer and their course content [3]. One of H5P's featured interactive content is interactive videos.

Interactive videos include many interactivities such as pop-up texts and labels, fill-in-the-blank, drag-and-drop, and multiple-choice questions [4].

2.3. ERP Systems

ERP systems are standardised, commercial software programmes with industry-specific best practices [14]. Moreover, ERP systems replaced outdated systems to prevent incompatible silo structures and data redundancy, save maintenance costs, and contribute to the creation of an enterprise-wide shared platform in response to the requirement for integrated solutions.

ERP integrates data from several business functions into a single system [15]. For organisations to function more efficiently, it is essential to merge all features into one system, giving staff in various departments access to the same data via a common database [14]. Many different ERP software solutions have emerged that cater to different organisations' varying requirements [16]. Notable ERP software solution companies include SAP, Oracle, and Sage [17]. Each company offers ERP software solutions with comprehensive functionalities and advanced features which integrate and manage core business processes.

Extensive training programs are necessary due to the complexity of ERP systems, making learning and comprehension challenging. A common factor of ERP implementation failure in organisations is the lack of ERP training [18]. An approach to ensuring the success of ERP implementation projects is providing employees with tutorials and videos customised to the specific ERP system implemented to provide hands-on experience [18].

2.4. Existing System Review

ERP software companies provide learning services alongside their software offerings. Three ERP learning tools were identified and reviewed based on interactive e-learning characteristics and the user experience of the e-learning simulation elements of the tools. SAP Learning Hub, Oracle University NetSuite, and Sage University's Education Partner Program were these systems.

SAP Learning Hub. This e-learning tool assists students in developing and maintaining SAP software skills by offering online, interactive, hands-on, and expert-led training to help students improve their skills through the SAP solution portfolio [19]. The data required to complete the learning activities are pre-loaded into SAP Learning Hub.

Oracle University NetSuite. This solution provides access to cloud-based business apps for instructors and students via a web browser, minimising the time and IT resource investment required by an organisation and making it simpler to include the most up-to-date business management tools in the learning program [20]. Oracle NetSuite solutions can either be preconfigured with wholesale distribution company data or remain unconfigured, allowing instructors and students to enter their data.

Sage University's Education Partner Program. Sage's program provides students with software, interactive experience, online support from Sage City, and industry-recognised certifications [21]. Sage University's Education Partner Program offers a comprehensive portfolio of training solutions through videos, and instructor-led training in virtual labs and webinars. Learners who complete the courses are awarded certifications.

The interactive e-learning characteristics reviewed for these three systems include real-life scenarios, graphics, relatable characters, real-life tools, assessments, and evaluations. Table 1 presents the review results, highlighting that all systems include interactive e-learning characteristics.

Table 1. Interactive E-learning Characteristics in Existing ERP E-Learning Tools

Interactive E-Learning Characteristics	SAP	Oracle	Sage
Real-life Scenario (Case studies)	x	x	x
Graphics	x	x	x
Relatable Characters (Roles)	x	x	x
Interactivity	x	x	x
Real-life Tools	x	x	x

Although the reviewed tools met the requirements of interactive e-learning tools, an important aspect of ERP e-learning tools is that these tools must have a good user experience. Therefore, these tools were assessed based on their user experience attributes, effectiveness, efficiency, and satisfaction. To assess the user experience of existing e-learning tools, user reviews and ratings from various software review and rating websites, including G2 and Indeed were evaluated. The user reviews were anonymised and paraphrased. The results of this assessment are presented in Table 2. The table shows that SAP's E-learning tool is effective and satisfactory but inefficient, while both Oracle and Sage's ERP e-learning tools are effective, efficient, and satisfactory.

Table 2. User Experience of Existing ERP E-Learning tools

User Experience Attributes	SAP	Oracle	Sage
Effectiveness	x	x	x
Efficiency		x	x
Satisfaction	x	x	x

Eighteen users rated SAP Learning Hub an average of four stars on G2.com. The high average rating indicated the platform's quality and effectiveness in delivering comprehensive training and education. The platform has garnered the trust and satisfaction of its users. However, user reviews on G2.com highlighted disadvantages, indicating that the SAP Learning Hub was difficult and inefficient to navigate.

Oracle NetSuite Learning Centre was rated an average of 4.3 stars by sixty users on Indeed.com. This high rating highlights that the platform has successfully met the expectations of its students, providing them with valuable skills and knowledge that enhance their professional growth and career prospects. There were no notable disadvantages indicated in the user reviews.

Sage University's Education Partner Program received limited online feedback, with only one review found. The user rated the program five stars. The review indicated that the tool positively contributed to career progression, as it incorporated video-based learning followed by assessments to reinforce observational knowledge. Additionally,

the reviewer praised the well-structured class program, highlighting the teachers' effective application of typical situations.

3. Research Methodology

The Design Science Research (DSR) methodology was adopted in the project from which this paper is derived. The purpose of this methodology is to develop an accurate and deep understanding of how artefacts can be designed in the field of information science [22, 23]. DSR focuses on the development and design of artefacts with the ultimate purpose of improving their functional performance. The methodology consists of five steps followed iteratively in designing and developing the e-learning tool. These steps are problem awareness, suggestion, development, evaluation and conclusion. The problem awareness and suggestion steps were performed through a literature review and extant systems review, presented in Section 2. The development steps are described in Section 4, and the evaluation is discussed in Section 5 below. The final step presents conclusions, which are presented in Section 6. The paper focuses on the final iteration of the development process.

4. Design and Development

The proposed tool was developed for learning ERP using Sage 200 Evolution, which is the ERP platform of choice at NMU. The tool was scoped to the Procure-to-Pay (P2P) and Sales Order (SO) processes of Sage 200 Evolution. The Timber and Steele Hardware case study was used for the ERP interactive video as it was used in the Sage 200 manual. The employee role was selected for the tasks to be simulated.

The proposed tool's requirements were elicited from lecturers and students at NMU. These helped ascertain the system's functional and non-functional requirements and the interactive e-learning characteristics discussed in Section 2.2. The functional and non-functional requirements are presented below.

- FR1: the ERP processes, sales and procurement should be presented in the ERP Interactive E-Learning Tool.
- FR2: the tool should use real-life case studies to evaluate real-life ERP scenarios.
- FR3: The tasks completed should be role-based, for example, organisation, customer, and supplier.
- FR4: the tool should use Sage 200 as the ERP tool to demonstrate the sales and procurement processes.
- FR5: An interactive video should be used to demonstrate complex ERP concepts.
- FR6: the ERP Interactive E-Learning Tool should incorporate interactive tasks.
- FR7: Quizzes should be administered throughout the tool to provide students with self-tracking and lecturer metrics for evaluation purposes.
- FR8: Number of tasks completed successfully or unsuccessfully to gauge a student's understanding of the content presented in the ERP Interactive E-Learning Tool.

The ERP Interactive E-Learning Tool implementation was limited to the core P2P processes, namely process purchase order (PO), process goods received voucher (GRV), and process standard supplier transactions, and the SO core processes, namely process quotes, process sales order, process invoices, and process credit notes.

The non-functional requirements of the ERP Interactive E-Learning Tool are security, performance and effectiveness. Regarding security, only students and lecturers of the ERP module should have access to the tool. When performing tasks, the tool should be efficient; in other words, the response time for tasks to be completed should not take longer than two to five seconds so that the user's attention is not lost.

4.1. User Interface Design

The chosen colour palette, namely blue, yellow, grey, and white, as seen in Figure 1. The blue is used for main headings, the yellow is used to highlight elements when hovered over, the grey is used for the font colour and symbols, and the white is used for the background. These colours were chosen because they are in line with the colour palette of the NMU Moodle site.



Fig. 1. ERP Interactive E-Learning Tool Colour Palette

Landing Page. The Moodle grid layout was chosen because of its minimalistic design, which uses a large web page area. Furthermore, the vectors selected for the cover images of each folder are minimalistic, aesthetically pleasing, and match the titles of the folders as can be seen in Figure 2. The vectors are also consistent with colour palette in Figure 1.

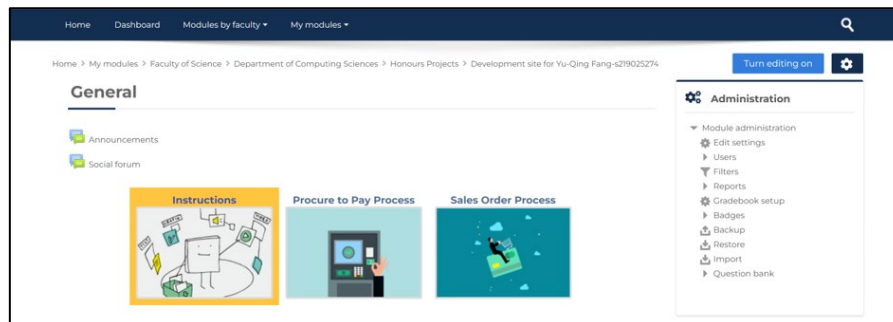


Fig. 2. ERP Interactive E-Learning Tool Landing Page

Instructions. The Instructions screen has two main steps – Step 1 involves watching an introductory video for the tool and Step 2 involves getting familiarised with the interactive video buttons. Any unfamiliar buttons or features were described and summarised in a table as seen in Figure 3.

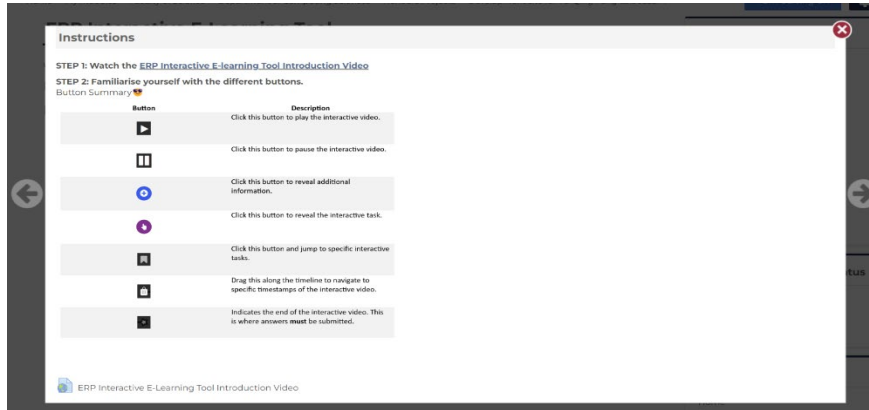


Fig. 3. Instructions Screen

Interactive Videos. Interactive videos for each ERP process were presented in respective lessons and saved in Lesson folders. H5P Interactive videos are indicated in the lesson with the H5P icon, as seen in Figure 4. The interactive videos open on a new page, as shown in Figure 5.



Fig. 4. Lesson Folder with H5P Interactive Video

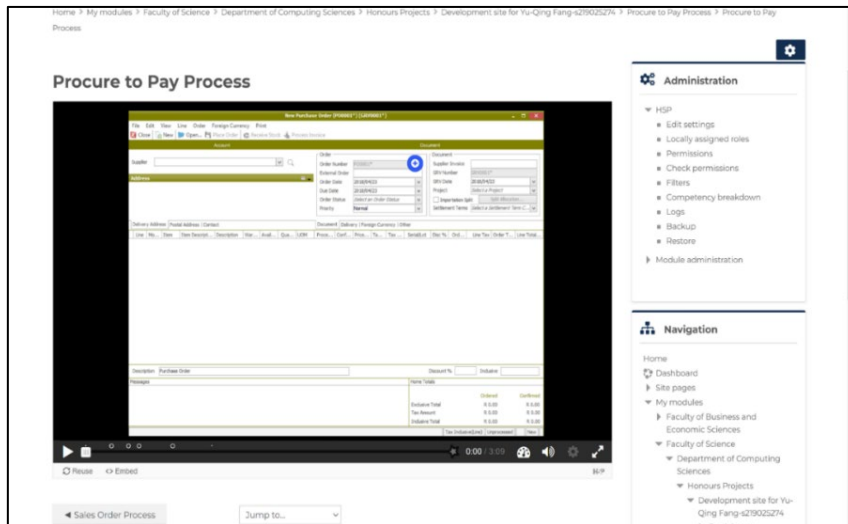


Fig. 5. Interactive Video Page

The videos incorporate a bookmark system and a progress bar, which provide viewers with a clear visibility of their current status, allowing viewers to easily navigate to the main interactive tasks, which must be completed before submitting all their

answers at the end of the interactive video, indicated with a star. The progress bar, bookmark system, and star are at the bottom of the interactive video presented in Fig. 6.



Fig. 6. Interactive Video Progress Bar and Bookmarks

4.2. Code and Data Requirements

The tool was developed using the inclusive and user-friendly H5P activity creation tools on the Moodle platform, which does not require any code or programming. These tools facilitate the creation of interactive activities through the completion of forms, effectively removing the requirement for coding. A separate database was not required either because the Moodle platform has its database that stores student information.

4.3. Video Content Creation

Open Broadcasting Software was used to record the ERP processes for the tool. MS Clipchamp was used to edit the videos and add background music. Royalty-free music from Pixabay was used for the background music of the video content. The video content was first uploaded on YouTube and then linked to Moodle. This approach served two purposes: first, it ensured optimised video quality was preserved. Secondly, it was an effective workaround to overcome Moodle's upload restriction of 500 megabytes (MB).

4.4. Interactivities

Various engaging interactivities have been integrated using H5P and Moodle for the Sage 200 Evolution P2P and SO Processes. The P2P subprocess interactivities are listed below and shown in Figure 7 as examples:

- Drag-the-words interactivities were used to assess PO navigation, order and document options revision.
- Drag-and-drop interactivity was used to assess PO form completion.
- True or false interactivity was used to assess the definition of settlement terms.
- Fill in the blank was used to assess completing the applicable reference as per the case study.
- Choose correct statement interactivity was used to recap view history description, and
- More information interactivity was used to display order and document options descriptions.

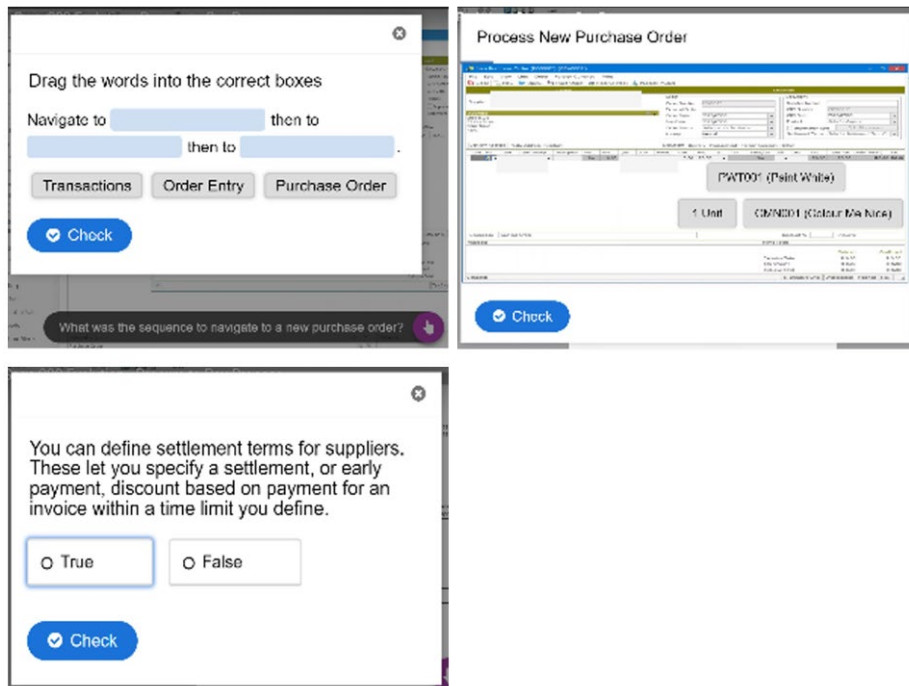


Fig. 7. Drag-the-words, True-or-false and Drag-and-drop interactivities

4.5. Feedback and Submissions

Feedback was provided for all incorrect interactivities (Fig. 8).

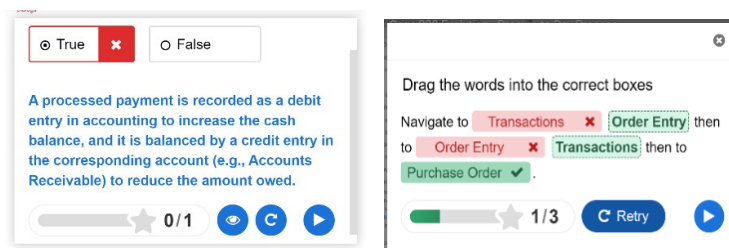


Fig. 8. Feedback for incorrect interactivities

Besides the submission screen available at the end of the interactive video (Fig. 9), submission screens were added at each subprocess's end. This allows students to submit their answers at different intervals of the video, preventing loss of progress in the event of disconnection from the internet or electricity.

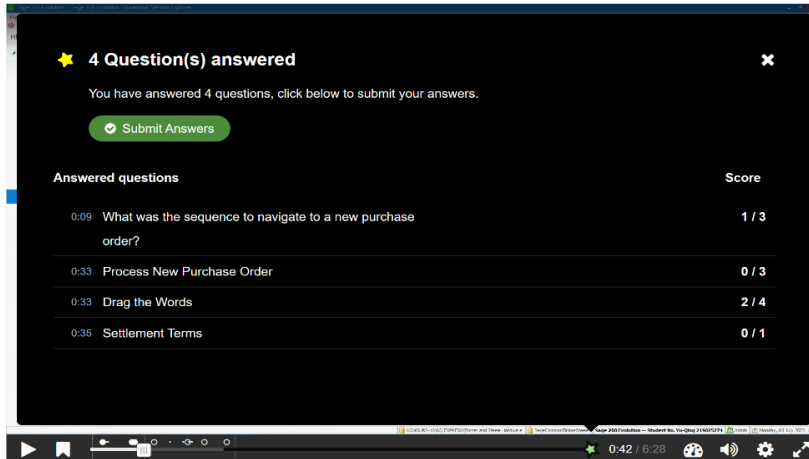


Fig. 9. Submission Screen

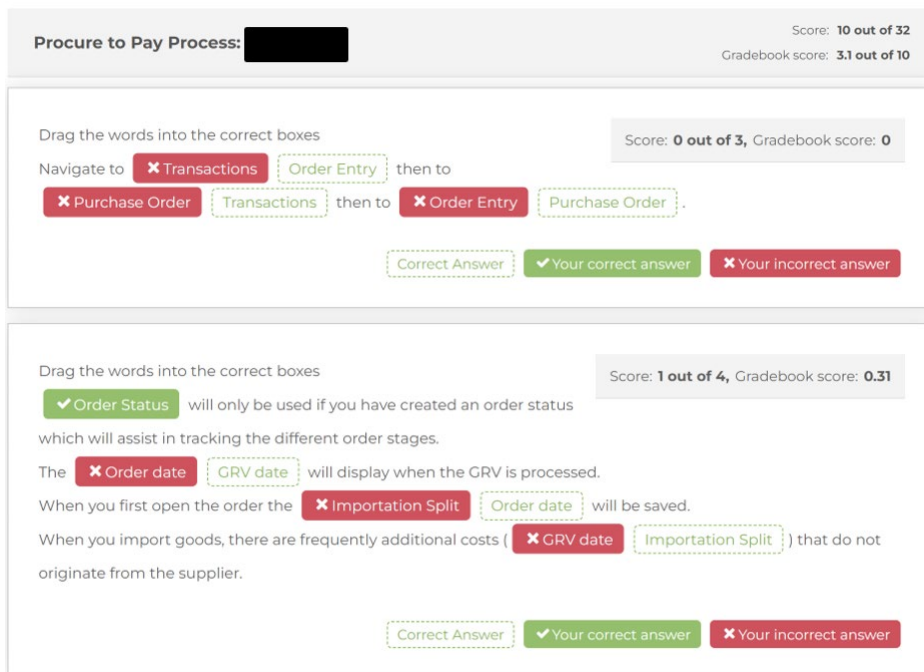


Fig. 10. Expanded Student Submission

Student submissions are recorded and are available to the lecturer in the Grader Report on a “Marks” page. When a student submits, answers up to the specific checkpoint are recorded. Any incomplete interactivities are recorded as incorrect in the Grader Report. Each student’s submissions can be expanded to get a comprehensive view of how the students completed the interactivities as seen in Figure 10.

5. Evaluation Design

An evaluation design is a structured approach used to assess the effectiveness of an artefact [24]. This design considers the ethical clearance approval to ensure that the research complies with ethical standards, procedures for selecting participants who represent the target users and evaluation procedures like usability testing to gather information and insights.

The study's ethical clearance was acquired, approved, and acknowledged by the Nelson Mandela University (NMU) Research Ethics Committee: Human (REC-H) under the reference number H23-SCI-CSS-003/U-05.

5.1. Participants

In adherence to the specifications of the ethical clearance acquired, the evaluation study participants were undergraduate third-year ERP students in the Computing Sciences Department of NMU. The selection criterion for participants was that students must have completed the ERP module because their understanding of and familiarity with learning ERP and related concepts are essential for evaluating the developed tool. Six students volunteered and enrolled to complete the usability study.

5.2. Evaluation Procedure

The usability study used standard desktop computers in a traditional computer lab environment. The main goal for the users was to get accustomed to the ERP Interactive E-Learning Tool and complete the interactivities within the interactive videos. Each participant used the tool to perform tasks in a specified task list. After completing the task list, participants were requested to complete a post-task questionnaire.

The evaluation utilised the standardised SUS questionnaire. The primary objective of the SUS questionnaire is to gauge the perceived usability of a system or product from the user's perspective [25]. The SUS questionnaire comprises 10 questions that respondents evaluate using a five-point Likert scale, where one indicates "strongly disagree" and five "strongly agree". Higher SUS scores signify that users perceive better usability, while lower scores indicate that users perceive poorer usability [25]. For the usability study, MS Excel was used to calculate each participant's SUS score and visualise the calculated SUS scores using graphs, which will be presented in Section 5.3.

5.3. Evaluation Results

The participants' responses to the positive and negative questions have been visualised in Fig. 11 (Positive) and Fig. 12 (Negative). Fig. 11 shows that most participants scored 4 or 5 on the positive scale indicating that they agree or strongly agree with the positive statements. This suggested that the participants found the tool to be user-friendly, efficient, and satisfying to use. From Fig. 12, it is evident that most participants scored between 1 and 3 on the negative scale, indicating that they strongly disagree, disagree or are neutral with the negative statements. This suggested that the participants found the tool simple, consistent, and easy to use.

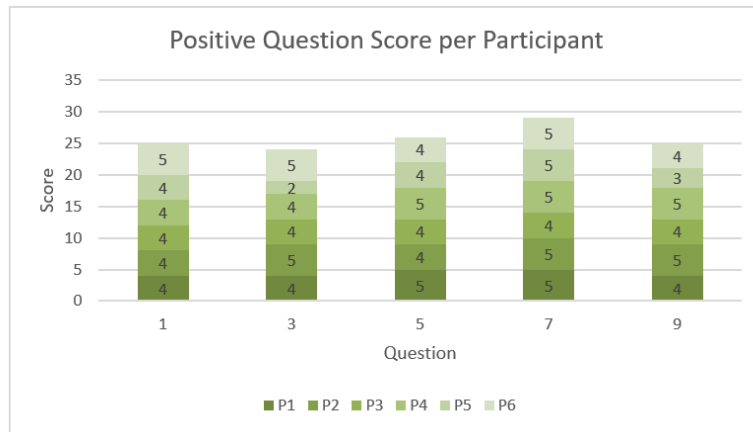


Fig. 11. Positive Question Score per Participant

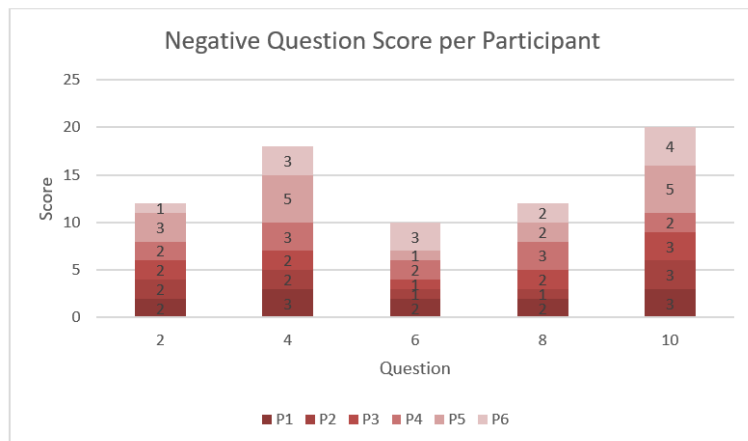


Fig. 12. Negative Question Score per Participant

According to [26], the benchmark average of the SUS score is 68, which was described as “Okay”. A SUS score of 80.3 was described as “Excellent”, scores between 68 and 80.3 were described as “Good”, and scores below 68 indicated that the system needed improvement. The SUS score is the sum of $(x-1)$ and $(5-y)$, multiplied by 2.5 [26], where x is the score for an odd-numbered statement and y is the score for an even-numbered statement. The SUS score of each participant, mean (73.75), and benchmark (68) have been visualised in Fig. 13.

As seen in Fig. 13, the SUS scores of five out of six participants were above both the average and the benchmark SUS scores, while one participant scored below with 55. Overall, the average SUS score was 73, which was above the benchmark SUS score; this indicated that the usability of the ERP Interactive E-Learning Tool was good.

Participants were also asked to provide qualitative feedback on their experience using the tool and suggest improvements. The feedback in Fig. 14 indicated the participants' overall experience was positive.

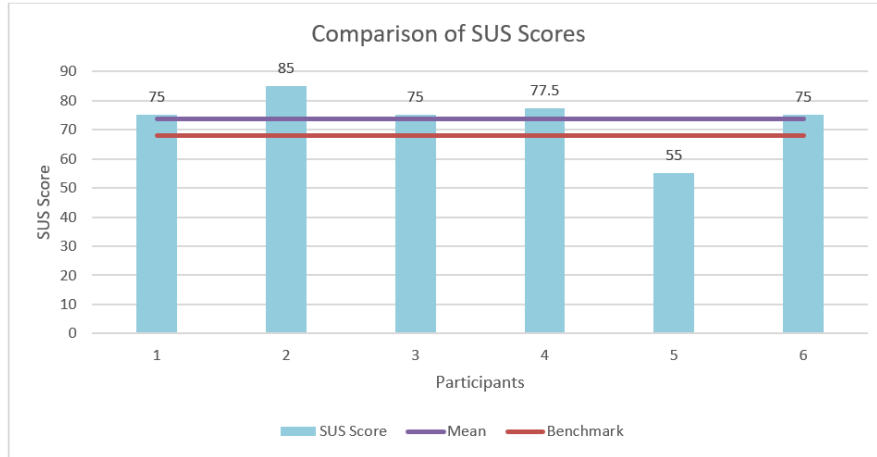


Fig. 13. Comparison of SUS Scores

Participant ID	Feedback
P1	It felt good to get total marks and it encouraged me to concentrate to get the stars. The constant pausing and manually having to play the video was a bit tiring. I found it hard to grasp the drag-and-drop functionality, but I finally got it. The notes and explanations make it easy to understand what you've gotten wrong and how to fix it. It reduces the pressure and anxiety that comes with getting answers wrong.
P2	The learning tool was very user-friendly and informative. The information on the screen must be a bit clearer. The tool also must accommodate both uppercase and lowercase for any answers that must be typed in so that the student isn't affected.
P3	Maybe a graphic of some kind to show when something is clicked and a way to zoom out on the word association questions so that you can see all your options regardless of what part of the question you are answering instead of having to scroll to the bottom.
P4	The pop-up with the instructions covers where the information needs to be filled in, making it harder to see the context needed in the background. The pop-up instructions/information can be less bulky.
P5	My experience with the ERP Interactive E-learning Tool is that it is very helpful and easy to use however it needs a walkthrough for first-time users.
P6	We could integrate with quizzes that can count [Avoid retry button] Very interactive [Wish I could have this first semester] Easy way of making SAGE a user-friendly tool. For the assistance, one lecture to explain can be useful but not necessary when use for next steps.

Fig. 14. Participant Feedback

The participants found the tool to be user-friendly and easy to use. The tool's interactive nature was described as informative and encouraging. Some suggestions were provided to improve the tool's usability, which were implemented in the final version.

6. Conclusions

Covid-19 was a catalyst for change in the education sector. Universities rapidly adopted technologies, including LMS. For modules like ERP involving complex systems, the lack of interactivity of some LMS platforms hindered student learning. The H5P plugin available on Moodle allows modules to be designed interactively. This paper presented the development of an ERP Interactive E-learning Tool that helps students learn about ERP systems and processes in a way that engages them and makes learning easy. The tool can be used at universities and in the industry for employees to learn about complex ERP systems and related concepts for the first time, as it provides a quick overview of ERP systems and processes. The development focused on only two ERP processes, the P2P and SO, which did not provide enough scenarios to handle the complexity of an ERP system in the real world. The evaluation study was also limited to a few students familiar with ERP systems; this could have led to biases in the evaluation process.

The tool could be extended to support other ERP modules and processes. The current tool was designed for just two processes, the P2P and SO processes. Furthermore, the tool can further include accounting processes like auditing to support accounting students in gaining quick access overview of complex accounting software.

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Cognitive processes used by students in understanding Aggregation and Composition in UML: A case of first-year BCIS students

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Abstract. Understanding UML concepts like aggregation, composition, and association is typically straightforward, both in definition and notation. However, first-year Bachelor of Computer Information Systems (BCIS) students often find these definitions and notations challenging when presented in UML diagrams. Therefore, it is essential to explore the cognitive processes of students as they grapple with these concepts. Exploring cognition in this context helps instructors understand how students transform received information into actual knowledge. This study aimed to achieve two objectives: first, to uncover the cognitive processes that students employ when learning or tackling problems related to UML concepts such as aggregation and composition, and second, to leverage this understanding to propose better ways of teaching these concepts to BCIS students. Employing an integrated methodological approach, data was gathered through asking questions (individual semi-structured interviews), artefacts, and observations. Thematic analysis of the data revealed key elements of the cognitive processes that participants found instrumental in helping them better understand UML diagram concepts, particularly aggregation and composition. Building upon these insights, practical recommendations were formulated to enhance the teaching of UML-related concepts, specifically aggregation and composition.

Keywords: Computer Science/Information Systems education, UML diagrams, class diagrams, cognitive processes, aggregation, composition.

1. Introduction

System and software developers use Unified Modelling Language (UML) diagrams to specify, visualise, construct, and document software systems artefacts. These diagrams are also used for business modelling and other non-software systems [13, 39]. UML uses a definite set of symbols to graphically represent various components and associations that exist within the system [16, 17]. The key advantage afforded by UML diagrams is the ability to describe and reflect the real world or information systems better [41]. Aggregation and composition are concepts of association that are specifically used in class modelling. Association is a concept that represents when one class uses the functionalities of another class. Aggregation is a relationship where a child object can exist independently of the parent object, while the child object cannot exist independently of the parent object in a composition relationship [7, 10, 32].

Irrespective of how simple the definitions of these concepts are, and the notation used to represent them is, first-year Bachelor of Computer Information Systems (BCIS) students are normally challenged by aggregation and composition, as some of the concepts that they (students) are taught and are linked to the UML diagrams. As such, it may be important to make attempts to understand what is going on in the heads (i.e., minds) of students when they learn the stated concepts. This introduces the concept of cognition in the whole process, as instructors may be willing to understand how information that students receive becomes actual knowledge [12]. Considering this angle (cognitive perspective), it may be necessary to comprehend the cognitive processes that students follow in trying to understand the learning concepts. Considerable research has been conducted on various aspects of UML diagrams [1, 5, 35]. However, there seems to be less research investigating specifically aggregation and composition (as some of the troublesome UML concepts) from the cognitive perspective, where cognitive processes (i.e., processes resulting in learning) that students follow are understood. As such, this study is set out to address the following research questions:

- What cognitive processes do students apply when learning or tackling problems related to aggregation and composition (as troublesome UML concepts)?
- How does insight into these processes help instructors to devise better ways of teaching these concepts?

The paper proceeds with a conceptual framework and literature review in Section 2, followed by research design and methods in Section 3, and results interpretation in Section 4. Section 5 discusses the findings, and Section 6 wraps up the paper.

2. Conceptual Framework

As this study is taking the cognitive perspective, cognitive learning aspects form a relevant component of the literature review. The cognitive learning theory, coined in 1936 by an Educational Psychologist, Jean Piaget, is grounded on the fact that knowledge is actively constructed in a human being's mind when he/she is learning [19, 27]. During this construction or learning experience, a learner actively engages in various cognitive or mental processes. These processes refer to a series of operations or procedures that students undertake to acquire and understand information or knowledge through their thoughts, experiences, and senses [12]. In doing this, students aim to transform information into easily manageable cognitive tasks. Literature identifies various cognitive processes that students apply during their learning experience. These include attention; memory; perception; reading, speaking, and listening; language and language development; learning as well as those processes related to reflective cognition [12, 20].

Using the *attention* cognitive process, a learner is triggered by a single stimulus or a host of stimuli to choose to use something or some things from the available possibilities at a certain point in time while performing a task. This implies that learners have a mental choice to apply selective attention (i.e., block out certain features of the environment and focus on one particular feature); divided attention (i.e., pay attention to two things at once); sustained attention (i.e., concentrate on a task, event or feature in the environment for a prolonged period); or alternating attention (i.e., alternate back and forth between tasks or activities) when performing a task or an activity over time

[20, 21, 37]. However, it is key to also note that attention is not unlimited, as educational psychologists have confirmed many times that the average person can only hold approximately two or three learned tasks in his/her attention at the same time. Furthermore, these psychologists state that the average person can only attend to one complex task at a time [12].

Information that students pay attention to has to be kept in some form of storage (i.e., long-term or short-term) [15, 24]. To achieve this, a learner applies the *memory* cognitive process. This process allows him/her to recall different kinds of knowledge that guide him/her to act or react in a specific way to certain stimuli. As there is a tendency for cognitive processes to overlap, students are likely to easily recall or remember something they pay more attention to [12, 31]. To avoid heavily engaging their memory in understanding aggregation and composition, BCIS students can use strategies similar to those used by programmers to understand computer programs. These include going back and forth during the learning or understanding process, reasoning aloud to enhance the memorability of concepts; highlighting, circling, annotating, or colouring some diagrams or text; writing comments; identifying patterns and making drawings or annotations (doodles) [14, 21, 23, 34].

Applying the *perception* cognitive process, students use their sensations (e.g., what an individual sees, hears, tastes, touches, and smells) to acquire information from the world around them. After acquisition, they transform it into meaningful experiences or signals that the brain can recognise and act upon [11]. Perception is cited as one of the most complex processes since it involves other processes (e.g., memory, attention, and language) [2, 31]. While performing a certain task, a sensation or a host of sensations can trigger a student's perception to change. When this happens, the perceptual span of such a student may either increase (positive sensation) or decrease (negative sensation). A positive sensation occurs when such a student obtains useful information, while a negative sensation occurs when the student encounters information that is difficult to understand [26]. A typical reaction to the negative sensation is to forget about information that is difficult to grasp and go to parts of the task which are not so difficult to understand [14].

According to Preece et al. [31], *reading, listening and speaking* are interrelated cognitive processes. Various authors [6, 22] indicate that students can demonstrate these cognitive processes through facial expressions, vocal behaviour, verbal consent, pauses or segregates, posture or stance, eye behaviour, hand gestures, and head movements. Analogous to strategies used in other cognitive processes, in an endeavour to understand aggregation and composition, BCIS students can mark some text and diagrams; write comments; make illustrations; and/or read through the text or diagram multiple times to enhance their comprehension [21, 23, 34].

When using *language and language development* cognitive processes, students try to understand and express their thoughts and/or feelings through words (e.g., spoken or written) [8]. These are some of the key cognitive processes when working with UML diagrams (including trying to comprehend aggregation and composition) as some notation is used to demonstrate existing associations within the diagrams. Inherently, students must be able to understand such notation to master UML diagrams. Literature has periodically confirmed that language and thought are closely related, and hence significantly impact one another [33, 43].

Learning is a cognitive process that students use as they take in new information, synthesise and integrate it with prior knowledge. Generally, learning happens through repeating various daily behaviours or habits and knowledge that students learn through various ways of conscious or unconscious interaction with the environment around them [3, 8]. As such, it can be deduced that learning occurs better when learners are engaged in physical learning activities and hands-on experiences. Educational psychologists including Piaget and Vygotsky have proven that cognitive learning occurs as a result of information that enters the learner's cognitive system and changes it. This change boosts the learners' self-confidence and engagement. Learners are further able to recycle and use the same learning methods that worked previously [4, 42].

According to Preece et al. [31], planning, reasoning, decision-making, and problem-solving are interrelated cognitive processes that enable individuals to reflect on their cognition (*reflective cognition*). Literature [18, 40] provides several questions that when addressed demonstrate the specific reflective cognitive processes that students are applying. These include: what should I do? (cognitive planning); what alternative courses of action do I have available? (cognitive planning); which alternative courses of action should I select to use? (cognitive reasoning); why should I use these (selected) alternative courses of action? (cognitive reasoning); and what are the consequences of using the selected alternatives? (cognitive decision making). Similar to computer programming, where students can use annotations or drawings or illustrations [23], BCIS students can also use these (annotations or drawings or illustrations or sketches) when learning or tackling problems related to aggregation and composition. According to Plowright [30], these annotations or drawings or illustrations are referred to as artefacts; while Lister et al. [23] use the name doodles to refer to them.

3. Research Design and Methods

3.1. Design

The study's design followed a narrative approach and adopted an integrated-methods research framework based on Plowright's [30] FraIM (Frameworks for an Integrated Methodology). FraIM, as a form of mixed methods design, suggests that no specific philosophical stance is required at the outset of the study. However, such a stance can emerge during the study's progression or during the interpretation of results. Narrative data for this study were gathered through asking questions, artefacts, and observations. The study targeted first-year Bachelor of Computer Information Systems (BCIS) students at a university in South Africa. The sample comprised students who willingly participated in the research activities. The selection of this sample was both purposeful [36] and convenient [25, 29]. It was purposeful because the students were enrolled in a module covering the concepts under investigation (aggregation and composition). Additionally, the sample was convenient due to the investigators' easy access to the participants, facilitated by one of the investigators (the second author) serving as the module instructor. Students in a class of 105 were informed about this study, and 20 were invited to participate on a first-come-first-served basis. Of these 20, only 11 were able to take part in the study. Before any data collection in this study, ethical clearance

was obtained from the appropriate ethical review board (Reference: UFS-HSD2023/1768).

3.2. Research Methods

As part of the ‘asking questions’ data collection strategy, primary data was collected using individual semi-structured interviews. Each interview had three phases, and the objective of each phase was to identify cognitive processes used by students when tackling the simple activity (phase 1); average activity (phase 2); and relatively challenging activity (phase 3).

When completing these activities, participants were given a pen and paper to use. Their answer sheets were collected and used as part of the ‘artefacts’ in analysing data. Participants were asked to use the think-aloud technique so that it would be possible to see the cognitive processes that they were using. The interview proceedings were audio recorded with permission from the participants. During each interview, the participants were ‘observed’, and their overall reactions were recorded in a research diary. This data was used as part of triangulation in the discussion of the overall findings of the study.

Phase 1 – During this phase, participants were asked whether they were familiar with each of Figures 1, 2, and 3. For each figure, participants were asked to carefully study it, and then explain what they could say about it concerning the concepts that they were taught in the selected module. The names of these figures were purposefully withheld for participants to work them out by themselves. However, Figures 1, 2 and 3 respectively represent association, aggregation and composition.

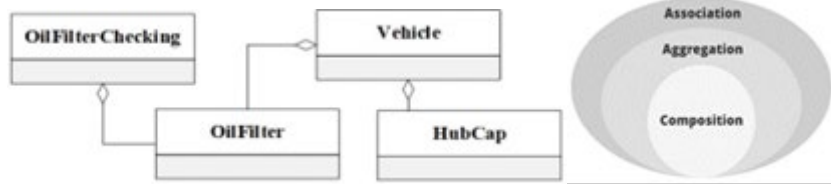


Fig. 1. Name withheld?

Fig. 2. Name withheld?

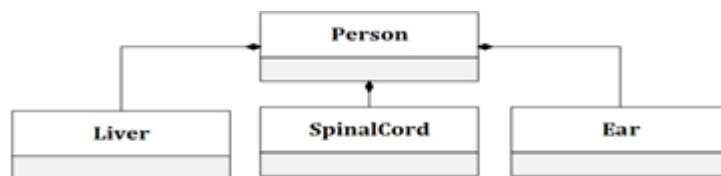


Fig. 3. Name withheld?

Phase 2 – During this phase, participants were asked to explain the relationships between the classes shown in Figure 4.

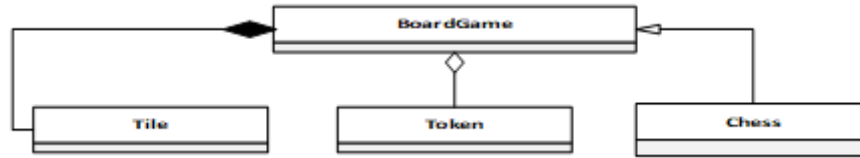


Fig.4. Boardgame class diagram

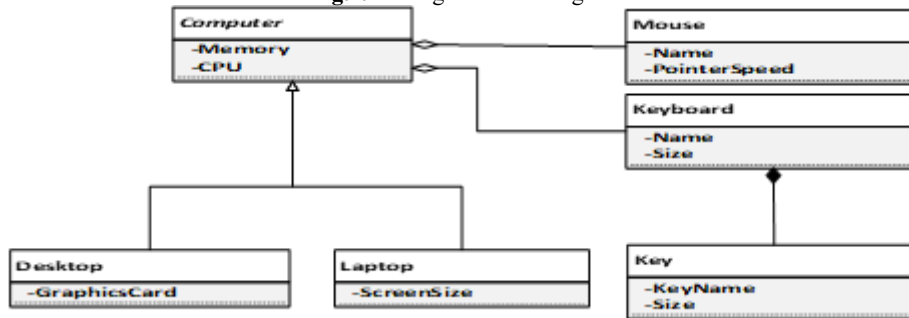


Fig. 5. Class diagram for a computer and its components

Phase 3 — This phase consisted of two activities. In the first activity, participants were asked to draw a class diagram based on these specifications: (i) A computer has the following private attributes: Memory and CPU. (ii) A mouse and keyboard are components of a computer. (iii) The mouse has the private attributes: Name and PointerSpeed. (iv) The keyboard has the private attributes: Name and Size. (v) A keyboard contains keys used for typing. A key has the private attributes: KeyName and Size. (vi) A desktop and laptop are types of computers. (vii) The private attribute for a desktop is GraphicsCard, while the laptop has a private attribute called Screensize.

In the second activity, participants were asked to explain the class diagram shown in Fig. 5 (*Note: This is the same basic diagram that participants were expected to produce in the first activity of phase 3*).

3.3. Data Analysis

In line with the established methodology of Creswell and Creswell [9], the audio recordings of interviews were meticulously transcribed and subjected to rigorous analysis. Initial cleaning of the transcribed data involved identifying and rectifying discrepancies particularly considering the open-ended nature of the questions, which sometimes led to illogical or repetitive statements. Given these challenges, a fuzzy validation approach was adopted, allowing for nuanced corrections that maintained the integrity of the data while ensuring coherence [28]. Subsequently, the researchers immersed themselves in the data through extensive listening sessions and thorough examination of the transcripts, iteratively refining their understanding and preparing for the coding phase. Drawing from this familiarisation process, a systematic coding plan was devised to align with the research questions at hand. The 11 validated transcripts were imported into the NVivo software for further analysis. The development of codes centered on emerging cognitive processes observed in the data, with careful

consideration given to the granularity of analysis units. Textual segments were systematically annotated and marked, facilitating the establishment of meaningful connections between codes and corresponding excerpts. Throughout this iterative process, code names were continually refined to accurately encapsulate emergent themes, with particular attention paid to the frequency of occurrence for each thematic element.

4. Results and interpretation

Analysis of the data collected revealed various elements of the cognitive processes that participants found instrumental in helping them better comprehend concepts related to UML diagrams, especially aggregation and composition. These processes are shown in Fig. 6, and discussed in the next subsections following the same order they were presented in Section 2. In this discussion, participants 1 to 11 are referred to as P1 to P11.

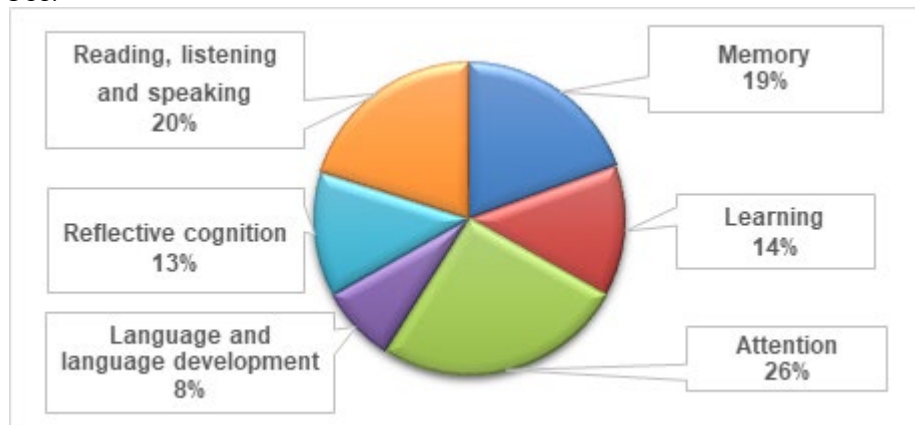


Fig. 6. Cognitive processes

4.1. Memory

A total of 27 occurrences of the elements of the memory cognitive process were identified in all the 11 study participants. In trying to understand concepts related to aggregation or composition, participants tend to recall information [12, 31] that relates to real-life examples taught in class. For example, if a pregnant mother dies, so does the child [7, 10, 32]. In this regard, P10 affirmed: *“I was taught that there is composition — If the mother can die, the kid will also die if the kid is inside the mother. And aggregation says if the bird dies, the feathers continue to survive”*.

While class examples may not always reflect real-world scenarios, they aid in information recall. Understanding these examples helps students relate them to current questions. Some students extend this by recalling class examples to connect them with present situations. About recalling information from the examples given in class, P2 said: *“If I’m given a question and asked about it, then I remind myself of an example I saw in the slides and textbook. In the example, they will show you that there’s a company here and then there’s an employee. Is this composition or aggregation? So, I*

noticed that this one is aggregation. So, to remind myself, I know that a company can exist without an employee — they are independent. So, I used that particular example. In this case, I have to draw it out to remind myself of what is happening in this particular example”. Apparently, students feel that it is imperative to know or remember the name or the type of diagram before they can identify any relationship. When tackling problems of a similar nature to the ones used in the interview, P6 emphasised: “*The first thing I do is to ask, what kind of diagram is this?*”. Additionally, P9 stated: “*When I first looked at Phase 1 — Activity 1, I started thinking about what type of diagram is that? I have to find its name*”. Moreover, P7 said: “*I can’t answer your question because I don’t remember the name of this diagram*”. Apparently, being able to identify the name of the diagram makes it easy for students to recall other relevant information related to it.

4.2. Learning

A learning cognitive process entails learning by repeating concepts or practicing them using exercises from class [3, 8]. Participants indicated that this repetition/practice helped them to better understand concepts related to aggregation and composition. Nineteen occurrences of this cognitive process were identified in 10 participants. As part of evidence to this finding, P11 stated: “*The lecturer gives out exercises and solutions. So, some other students solve a problem by looking at how she solved that particular one. So, you look at the question how she did it, now also do that*”. Since repetition is inherent in the learning cognitive process [3], students can repeat concepts in the different modules which could help them learn the concepts better. Regarding this issue, P8 emphasised: “*Another thing that makes me understand whatever the diagram is trying to explain is that, in one of the modules that I’m doing, which is programming, similar concepts are also discussed. So, there’s a connection and that’s how I remember. Like, okay, this is the base class, and that one is a derived or main class and it does this*”. As can be seen in this excerpt, as part of the learning cognitive process, it was a key revelation to see P8 also identifying the relevant technical concepts in UML diagrams though the questions did not specifically request for them.

4.3. Attention

It was interesting to observe that for questions that had diagrams, participants scanned or focused on the diagram first before reading the question specifications. Thirty-six occurrences of this cognitive process were identified in all the 11 participants. When asked about the initial focal areas when tackling UML-related questions that had diagrams, P6 said: “*I look at the diagram*”. On the other hand, P5 stated: “*I analysed the diagram first*”. Participants provided several reasons for focusing on the diagram at the beginning of the activity. The reason provided by P9 was “*trying to figure out what the name of the diagram is*”, while P11 indicated that she wanted “*to have an idea of the concepts that are in the diagram*”.

Ultimately, it seems imperative to participants that they should see whether there are concepts they know before reading what the question requires. To this, P10 attested: “*I always start by analysing the diagram to see what I have on it before I go to the question to check what I’m asked to do. Sometimes I even write reminders outside of the given diagram before I go to the question, in case I am asked something that I already wrote*”.

down”. From this excerpt, it can be deduced that P10 would likely have a list of key aspects to consider going forward into the question, hence making it easier for her to know what to pay attention to. Although creating this list of aspects could be regarded as time-wasting, it was key to note that some participants did not see it this way. For example, P8 maintained that it is important to analyse the entire diagram before going to the problem specifications: *“Questions can start with the end of what it is needed to be done with the diagram. That is why I always go and fully study or analyse the diagram. Then after that I read the question to find out whether what is in my analysis is present in the question or not. Then I will only take what is needed from what I have analysed”*.

4.4. Language and language development

Language was an important contributor to students in understanding aggregation/composition concepts they were asked about. Eleven occurrences of this cognitive process were identified in eight participants. It was key to note that students need to understand the jargon/language used to describe the notation used in drawing the UML diagrams. As an example, P3 said: *“By the look of symbols — this symbol here is not shaded, it is not coloured, and then the one that is not shaded shows that it is an aggregation”*. It was interesting to observe that some participants who had forgotten the names of the relationships (aggregation/composition) could interpret the meaning of the symbols because of the familiar terminology. When working on Phase 1 – Activity 1, P4 could not recall the concepts related to the names of relationships and their meanings. However, when he got to the next activity, he recalled these concepts when seeing familiar terminology that he could identify with: *“I’m looking at Phase 1 – Activity 2 right now to try and remember the relationships because I think a liver cannot exist without a person, and a person cannot exist without the liver, because here we have the shaded diamond”*.

Better yet, when answering questions where familiar terminology was used, participants managed to correctly guess the meaning of the symbols in question. P5 did not remember the names of the relationships and diagrams, but because he was familiar with the components of a vehicle, he started by assuming that one component was dependent on another. In this regard, he said: *“The way I see it, is that the oil filter and oil checking, one is dependent on the other. So, what I’m thinking now is that the filter checking is dependent on the oil filter”*. It was also worth noting that the use of unfamiliar terminology can lead to incorrect interpretation of a question. For example, Phase 3 – Activity 1 required participants to draw a class diagram based on the provided specifications. The interviewers observed that many students found it challenging to interpret specification #ii (see the first activity of Phase 3 – Section 3.2). The specification stated that the mouse and the keyboard are components of a computer.

4.5. Reflective cognition

Participants expressed their thoughts by underlining keywords, writing down concepts, and even circling the notations in the diagrams [21, 23, 34]. Eighteen occurrences of this cognitive process were identified in all the 11 study participants. Underlining keywords was prevalent in the activity that required participants to draw a class diagram based on the given specifications. When asked the rationale for

underlining, P11 responded: *“I underline everything that I think is important for that certain instruction because I have enough time. At other times, like in the Test, I won’t have enough time to even recheck my steps. That’s why when I am doing it, I make sure to write down notes”*. This excerpt suggests that in exams, students must revisit question specifications to ensure comprehensive consideration of all stated aspects. Due to time constraints, some students underline key concepts, allowing them to focus on them during subsequent revisions of specifications. It was also interesting to observe that P11 forgot to underline a certain concept while reading the specifications. Consequently, she forgot to include it in the diagram. Additional to underlining keywords, some participants were observed writing down concepts as they remembered them, labelling diagrams to demonstrate their cognitive processes, and circling notations that demonstrated the relationships in the various diagrams.

4.6. Reading, listening and speaking

Analogous to strategies used in other cognitive processes, to understand aggregation and composition, BCIS students can mark some text and diagrams, write comments, make illustrations, and/or read through the text or diagram multiple times to enhance their comprehension [21, 23, 34]. Participants were observed to be reading the text multiple times to enhance their comprehension. The listening and speaking aspects of these interrelated cognitive processes [31] were not measured because of the nature of the activities that participants had to work on. For example, participants were mainly asked to read and intensively work through the activities on a piece of paper though they were speaking aloud throughout the interview session.

Twenty-eight occurrences of this cognitive process were identified in all the 11 participants. This was demonstrated especially in Phase 3 – Activity 1, where participants had to draw a class diagram based on the provided specifications. Participants employed two distinct approaches in tackling the activity. Some began drawing the diagram immediately after each instruction, gradually expanding it. Conversely, others read all instructions before drawing. Yet, both groups shared a tendency to revisit previous instructions when encountering comprehension issues with the current ones. When asked why he seemed to be stuck on instruction #v ii (see the first activity of Phase 3 – Section 3.2), P8 said: *“Actually it makes me go back and check whether whatever I have explained and just analysed on top [previous instruction] is correct. Because it says a keyboard contains keys and the keys are used for typing and here on instruction #iv, it says the keyboard has the private attributes, name and the size”*.

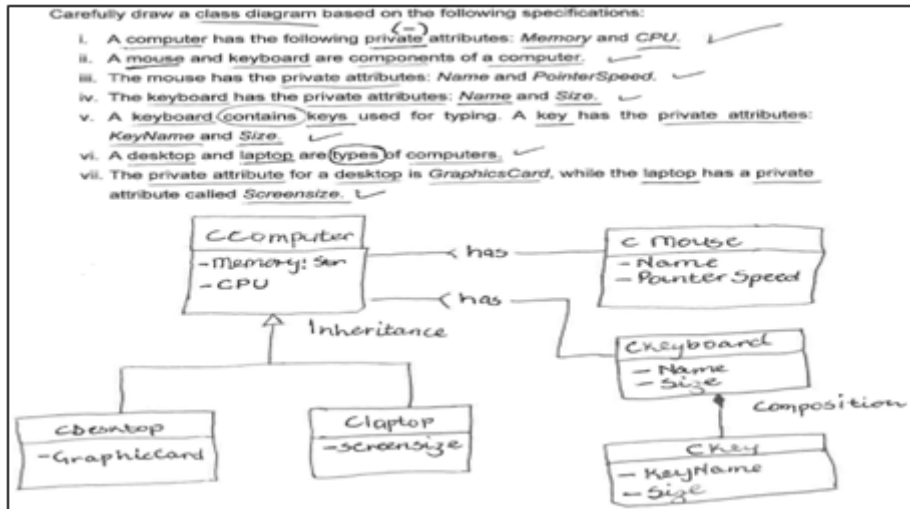


Fig. 7. P1's artefact for Phase 3 – Activity 1

Participants who used the first approach seemed to draw the diagram with some elevated struggles compared to those who used the second approach. Those who used the first approach constantly changed their minds about what they deemed the instructions required. As a result, they frequently erased parts of the diagram when they read the subsequent instructions. Some participants opted to use the second, rather than first approach. When asked why she read the first to the last specification before drawing the diagram, P9 responded: *“It’s important to look at the whole picture first, and then carry on with it. I tried it before where I read the first specification and drew the diagram. It doesn’t work – It wastes time because then you have to erase and then redraw”*. The interviewers observed that some participants skipped instructions that were challenging to comprehend, but they would return to them later in other instances. It was further observed that participants such as P1 used ticks to mark the completed instructions to ensure that they did not waste time revisiting them (see Fig. 7). This strategy also helped participants not to mistakenly leave out any parts of the specifications unaddressed.

5. Discussion of Results

This study has revealed insights into students' cognitive processes when tackling activities related to UML concepts, particularly aggregation and composition. Awareness of these processes empowers instructors to improve teaching methods, aiding students in comprehending these concepts. The findings suggest multiple avenues for instructors to enhance teaching effectiveness in UML diagram-based concepts.

As part of being *attentive* to the relevant UML-related concepts, it was key to note that participants prioritised the analysis of UML diagrams before getting into the specifics of related questions. Reasons advanced for this tendency such as identifying

the type of diagram and understanding related contents suggest that it is important for instructors to integrate visual aids into their preparation of UML-related content to teach to students as they can serve as effective tools for facilitating comprehension and strategic problem-solving amongst students. Since this approach promotes deeper engagement with the learning content and helps students extract useful information from complex UML diagrams, instructors should encourage it to their students. Deciding what to be *attentive* to when tackling UML-based problems is key as information gained in one step of the process cognitively informs what students must do or perform next. In agreement with the literature [20, 21, 37], this channels the cognitive resources of such students to relevant focal aspects to avoid the student being cognitively overloaded [12] with information that may not be necessary at that particular moment.

It was also noteworthy to see the findings highlighting the pragmatic value of class examples in helping students recall information related to UML examples seen previously in class [7, 10, 32]. Additionally, it was key to see the significance that participants placed in knowing the name or type of diagram, as it serves as a crucial anchor for recalling associated information (*memory*). This underscores the importance of providing clear categorisation and labelling in UML diagrams to facilitate students' comprehension and retention of related concepts. Instructors should, therefore, acknowledge and leverage this reliance on examples by ensuring that they are effectively integrated into teaching UML-related concepts, thereby enhancing students' ability to connect theoretical concepts with practical applications.

As literature indicates that *perception* involves other cognitive processes such as memory, attention, and language [31], it was not easy in this study to specifically identify this cognitive process. However, attention and memory cognitive processes have surfaced in the above paragraph though not integral in perception. Concerning *language and language development* [33, 43], it is key to note that while it is imperative for students to be able to identify, name, and understand symbols in the class diagrams, the instructor can use familiar terminology for class names to make it easier for students to comprehend the meaning of such notations. Furthermore, using examples familiar to students (e.g., considering student demographics, and social circumstances) can also assist students to better comprehend the concepts. Considering this study's participants, males might have identified better with the class diagram of a vehicle than females. However, the class diagram of the human physiology was likely to be more relatable to all participants irrespective of gender.

The findings further highlight that understanding the specific terminology and jargon (*language and language development*) associated with diagram notations significantly aids students in interpreting relationships. Participants demonstrated an ability to infer the meanings of symbols used in the UML diagrams even when they could not recall [12, 31] formal names of relationships, showcasing the importance of familiar language in facilitating comprehension. The ability of participants to leverage familiar terminology to recall relevant UML concepts further emphasises the importance of creating connections between theoretical knowledge and everyday language [38]. As a result, instructors should strive to provide linguistic scaffolding to enhance students' understanding of the technical content of the subject.

Regarding *reflective cognition*, it is worth noting that during class diagrams' discussions in the lectures, the instructor who helps students identify keywords by

emphasising them, will help such students to easily know what to concentrate on when drawing class diagrams. This could be done by applying font effects such as bold, underlining, font colour, and text highlighting [14, 21, 23, 34]. Notably, underlining keywords emerged as a common practice that allowed participants to focus on essential elements of the instructions and ensure comprehensive coverage of the specified criteria. However, the importance of these strategies was further highlighted by the recognition that time constraints, especially in exam settings, may limit opportunities for thorough rechecking. Instructors should encourage and support the development of cognitive strategies to enhance students' learning experiences and outcomes in learning UML-based concepts.

A take-home regarding the *reading, listening, and speaking* cognitive process category [31] is that a question that involves drawing a class diagram should have related steps (relationships concerning a specific class) grouped and listed sequentially. This will help students to quickly get clarity on the steps they are unsure of. The study participants went to the previous specifications/steps when they sought clarity on some concepts [14]. This approach seemed to help them better comprehend what the question required. Apparently, a good practice when tackling a question that requires drawing a class diagram with given specifications, is to read all the specifications first to get a holistic view of the question and then draw the diagram one step at a time. Furthermore, specifications that have been completed and those that have been skipped should be marked differently to provide allowance for revisiting the incomplete specifications. When all specifications have been addressed, they should have the same type of marking [21, 23, 34]. With these two practices, students can ensure that they have answered all the specified questions and avoid losing time due to redrawing caused by misunderstandings that could have been clarified earlier had all the question specifications been read initially. Instructors teaching class diagrams should encourage students to practice these techniques when tackling questions that require drawing diagrams.

The findings further suggest that *learning* is a dynamic cognitive process influenced by various factors such as engagement in physical activities, and hands-on experiences. As learning occurs through repetition [3, 8], it was further key to see findings underscore the significance of repetition and practice in the learning cognitive process, particularly in helping with the understanding and retention of complex UML concepts. This suggests that instructors should incorporate opportunities for repetition and interconnection of UML-related concepts to foster deeper learning and comprehension among students.

6. Conclusions and Future Research

The understanding of UML concepts such as aggregation, composition, and association is often deemed straightforward within the academic realm. However, it has been observed that first-year Bachelor of Computer Information Systems (BCIS) students commonly face challenges in grasping both the definitions and notations associated with these concepts when presented in UML diagrams. This discrepancy prompts an exploration into the cognitive processes underlying students' comprehension, highlighting the importance of understanding how information transforms into knowledge within their minds.

Consequently, this study pursued a dual objective. First, to uncover the cognitive processes that students apply when learning or tackling problems related to aggregation and composition (as troublesome UML concepts). Second, to leverage this understanding to propose more effective pedagogical strategies for teaching these concepts to BCIS students.

Employing an integrated methodological approach, data was gathered through asking questions (individual semi-structured interviews), artefacts, and direct observations. Thematic analysis of the data unveiled a spectrum of cognitive elements pivotal to enhancing students' comprehension of UML diagram concepts, particularly those pertaining to aggregation and composition. Building upon these insights, practical recommendations were formulated to enhance the teaching of UML-related concepts as mentioned throughout the discussion in Section 5. However, it cannot be conclusively argued that the identified students' shortcomings (e.g., focussing on diagrams and interpreting what concepts are required of them before reading all the question specifications) are the sole reason for their misunderstanding of UML concepts. Other factors exist such as the instructor's incompetence (e.g., inability to explicitly explain concepts, and provide relevant examples).

The implications of this study extend beyond the confines of the BCIS curriculum, offering valuable insights to educators across the broader academic community tasked with delivering modules covering UML-related material. Future research endeavours could explore similar themes in alternative educational settings, potentially involving participants from higher-level BCIS modules and diverse instructional contexts.

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Enhancing UX in Learning Management Systems: Leveraging Design Thinking for the Development of Chatbot Design Principles

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Abstract. This paper presents the exploration of a Design Thinking Workshop as a data collection technique during the development phase of a Design Science Research (DSR) study. Utilising the Stanford d.school five-stage design thinking process, this study concentrates on understanding the needs of users of Learning Management Systems (LMS) in Higher Education Institutions (HEIs) and examines how these needs can be fulfilled through the integration of a chatbot into an LMS. The workshop adhered to a user-centric methodology, highlighting empathy, definition, ideation, prototyping, and testing phases.

The "Empathise" stage of design thinking involved structured interviews and notetaking to capture the experiences and expectations of the students. Subsequently, the "Define" stage identifies student's needs, frustrations, and problems, leading to the development of a Point of View (POV) statement. The "Ideate" stage encouraged brainstorming, utilising "how might we" statements to generate creative solutions. The "Implementation of the prototype of design principle" stage resulted in a low-fidelity LMS chatbot prototype, created collaboratively. The "Test" phase gathered informal feedback, refining the prototype which informed a tentative set of design principles.

The study analysed workshop outputs using the UX honeycomb with the aim to enhance the student's user experience (UX) in LMS. The findings indicated a tailored approach to design principles that addressed the specific needs of students, using the LMS, emphasising a user-centric perspective.

This research contributes insights into the application of Design Thinking in the development of LMS chatbots, offering actionable guidelines to improve enhance students' UX in HEIs.

Keywords: Design Thinking Workshop, Learning Management Systems (LMS), User-Centric Design, UX.

1. Introduction

1.1. Research problem and objectives

Improving the user experience (UX) of Learning Management Systems (LMS) within Higher Education Institutions (HEIs) remains a significant challenge for service providers. This challenge is primarily due to the limitations inherent in current user support mechanisms within LMS platforms. Many LMS platforms lack established design principles for chatbots, both in theoretical frameworks and practical applications, which complicates the integration of efficient user support through chatbots [1]. The absence of these principles not only hampers the development of effective support tools but also increases the risk of user dissatisfaction. Such dissatisfaction can lead to frustration among users, which may prompt HEIs to seek alternative LMS products or service providers.

Given this context, the motivation for this study lies in the need to bridge these gaps. By addressing the challenges related to the integration and utilisation of chatbots, this research aims to enhance the overall UX of LMS platforms within HEIs [2]. This study seeks to develop and propose effective design principles for LMS chatbots, ensuring they are not only theoretically sound but also practically applicable. The goal is to facilitate a smoother, more supportive UX, thereby increasing satisfaction and reducing the likelihood of institutions switching to different LMS solutions, by exploring the use of a design thinking workshop as a data collection technique in developing LMS chatbot design principles during the development stage of Design Science Research (DSR).

The structure of this paper is as follows: the next section presents a literature review, outlining existing research and identifying gaps that this study aims to fill. This is followed by the research methodology section, which details the approach and methods used to conduct the study. Subsequently, the research findings are presented, providing insights and data supporting the proposed design principles. The research findings section summarises the key findings, discusses their implications, and provides recommendations for LMS service providers. Finally, the paper addresses the limitations of the study and suggests directions for future research.

2. Literature review

LMS play a crucial role in HEIs by providing a comprehensive platform for managing educational courses and content. An LMS is a server-based software program that stores information about users, courses, and content, creating a flexible learning and teaching environment that transcends the constraints of time and location [3][4]. These systems facilitate communication, content delivery, evaluation, application integration, and course administration, contributing to an enhanced learning experience [5].

Despite their benefits, current LMS implementations face significant UX challenges. Common problems include complex navigation, lack of user-friendly interfaces, limited customisation options, and inadequate mobile accessibility. These issues can

hinder both instructors and students from effectively engaging with the platform, ultimately affecting the learning process.

To address these UX problems, various solutions have been proposed and implemented. These include redesigning interfaces to be more intuitive and user-friendly, offering personalised learning experiences through customisation options, and improving mobile accessibility to ensure that users can access the LMS on various devices. Efforts have also been made to enhance the integration of LMS with other educational tools and applications, providing a seamless experience for users [6]. Such improvements aim to create a more efficient and effective learning environment within HEIs, addressing the evolving needs of both educators and students.

The literature on chatbot design offers valuable insights for creating effective chatbots across various domains [7]. However, there is a significant gap in research explicitly addressing the design principles needed for chatbots in LMS environments.

Studies have highlighted the advantages of incorporating chatbots into LMSs, such as enhancing user engagement, supporting multilingual interactions, and leveraging AI for personalised learning experiences [7]. Yet, these studies often do not provide detailed, LMS-specific design guidelines.

For instance, research by [8] explores the integration of chatbots within LMSs but does not offer specific design principles tailored to these systems. Other researchers, such as [9], [10], [11], and [12], provide general insights into chatbot design but overlook the unique challenges and requirements of LMS chatbots, particularly those targeting student users. Even studies that propose chatbot design principles grounded in theories such as self-determination [13] fail to adapt these principles to the LMS context. Furthermore, while some research acknowledges chatbots' potential to enhance student learning [14] and provides educational design principles for AI chatbots supporting self-regulated learning [10], these principles are not tailored to LMS integration. The lack of LMS-specific design principles underscores the necessity for focused research to bridge this gap.

A potential solution to this problem is a set of well-defined guidelines and research-based design principles tailored specifically for integration within LMSs. Such design principles are necessary for service providers aspiring to improve the UX within the LMS environment. With the objective of advancing the product delivered to its users, the researcher proposes the implementation of an LMS-integrated chatbot, setting it apart from existing chatbots that lack integration and empirical research foundations.

To address this problem, the study employs the Design Science Research (DSR) methodology and incorporates a design thinking workshop approach during DSR's third phase: development. The workshop convenes a diverse design team consisting of 12 members, all of whom are active LMS users from various HEI environments. This team includes four students, four instructors, and four LMS administrators. Their participation in the workshop provides valuable insights into not only the desired appearance, functionality, and UX of an LMS chatbot but also how these aspects can enhance the overall LMS experience for students.

By involving administrators, the design team gained insights into system-wide considerations, such as data management, privacy concerns, and integration with existing LMS infrastructure. Instructors contributed their perspectives on pedagogical

needs, course content organisation, and communication preferences, which directly impact students' interactions with the chatbot. Their input ensures that the chatbot aligns with instructional goals and complements the teaching-learning process effectively.

Thus, while the focus remains on meeting students' needs, the involvement of administrators and instructors ensures a holistic approach to designing an LMS chatbot that enhances the experiences of all users within the educational ecosystem.

Data gathered from the workshop included participant worksheets, observations, and field notes, which served as the groundwork for a tentative set of LMS chatbot design principles. These tentative principles underwent evaluation by four LMS experts to ensure their relevance and effectiveness in enhancing the LMS UX. The resulting design principles provided a structured framework guiding the creation of LMS chatbots to enhance the LMS UX within HEIs, aligning them with the seven facets of the UX honeycomb [15]. The focus of this paper is only on the design thinking workshop's outcomes regarding students' needs for an LMS chatbot. However, it also briefly discussed the contributions of administrators and instructors to the overall design process and how their insights influence students' experiences with the LMS.

3. Research Methodology

The necessity to formulate design principles for LMS chatbots, grounded in empirical evidence, has been substantiated. The proposed DSR methodology involves developing design principles informed by empirical evidence.

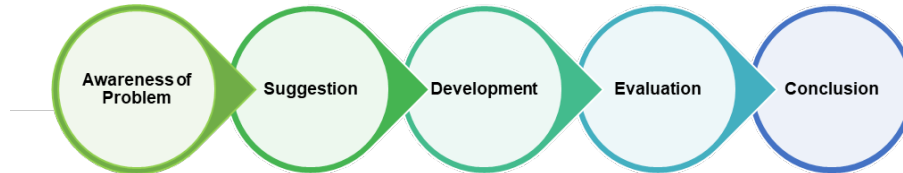


Fig. 1. DSR process steps or phases adapted from Vaishnavi and Kuechler [16]

DSR methodology consists of five phases (Fig. 1). In Phase 1, the researcher explored the problem through informal conversations with students and drew from first-hand experience as a university instructor to identify challenges in LMS usage. This problem awareness aligns with findings from studies by [17], [18], and [19]. These studies shed light on the limited utilisation of LMS platforms, primarily restricted to accessing content and announcements. Furthermore, they highlighted issues such as limited availability of LMS platforms, lack of real-time responses to student inquiries, and dependency on instructors' online activity for responses.

A well-defined problem statement emerged, guiding subsequent phases. Phase 2 involved suggesting LMS chatbot design principles based on literature and best practices. Phase 3 focuses on development. A design thinking workshop resulted in a basic prototype chatbot using Figma software. Key themes from the workshop data form a tentative set of design principles. In Phase 4, the researcher evaluated the design principles with four LMS experts using a structured questionnaire. A real-life LMS

chatbot is used to illustrate principles and gather feedback. The artefact was refined based on expert feedback, resulting in a final set of design principles. Phase 5 concludes the study with the researcher communicating findings.

This article is dedicated to addressing the research question, with a specific focus on elucidating the design principles guiding LMS chatbot development: “What design principles guide the development of an LMS chatbot?” The overarching objective is to align these guidelines with the diverse needs of LMS users, ultimately contributing to the development of a chatbot that enhances the overall LMS UX.

3.1. Design Thinking

Design thinking has emerged as a valuable approach for fostering value creation and innovation across diverse fields, including business, medicine, science, and various educational stages [20]. Design thinking has witnessed increasing popularity in HEIs contexts in recent decades [21, 22, 23, 24, 25]. Results from a recent review study on design thinking reveal its strong association with educational settings, emphasising skills such as collaboration/teamwork, creativity, problem-solving, and empathy [26]. Design thinking has thus proven to be a versatile and effective methodology for encouraging innovation and skill development, particularly within the context of HEIs. Although the types of users differ, the resulting DPs showed similarities across different user types. For that reason, the user discussed in this paper refers to students only.

The Stanford d.school five-stage design thinking process encompasses the following phases: empathy, definition, ideation, prototyping and testing [27] (See Fig. 2.).

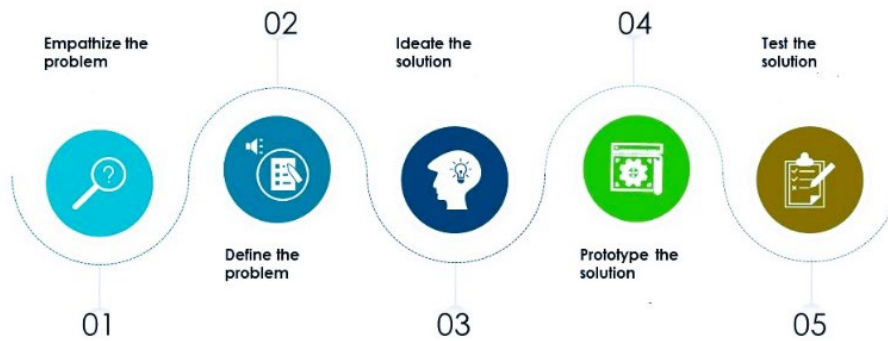


Fig. 2. The Stanford d.school five-stage design thinking process [27]

Stage 1: Empathise. Empathy entails envisioning oneself in someone else’s circumstances, gaining a genuine understanding of their perspective, and comprehending their needs [28]. For designers, cultivating empathy is vital in making informed decisions, particularly in grasping users’ emotional responses. This empathetic approach ensures the development of products that resonate with users, enhancing their overall experience.

To cultivate empathy, team members initiated the process by posing questions during two occasions (interviews) to each participant within their team to comprehend the problem or need by taking notes. Following this, team members actively listened to the other members’ stories, concentrating on absorbing the nuances of their

experiences. Moreover, they paid close attention to the participants' body language and reported their observations through notetaking. The goal was to document and capture the essence of the participants' experiences, creating a comprehensive record for a more empathetic approach.

During the first interview, the participants completed a worksheet, which included typical questions such as: What do you expect from a chatbot in an LMS? What should it be able to do for you? What should it not do? How should it do this? As a student? As an instructor? As an administrator? See Fig. 3, for an example.

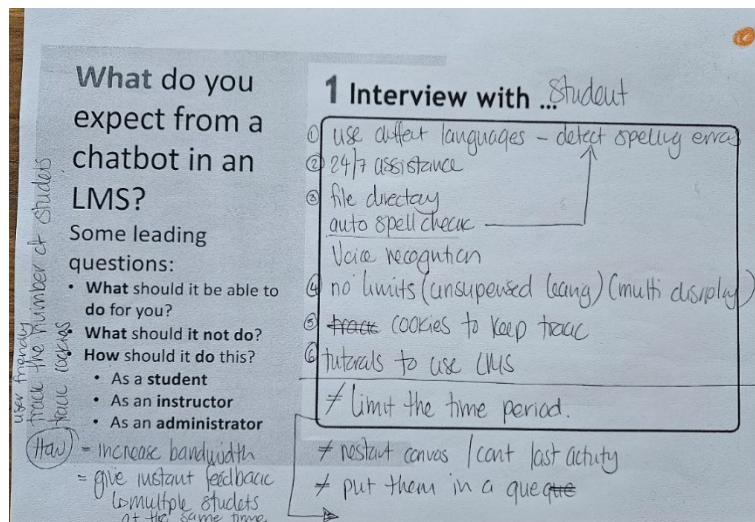


Fig. 3. Participant Worksheet 1: Interview with student

Stage 2: Define. The "define" stage aimed to identify the needs, frustrations, and problems that users experience while working in an LMS [28]. The team was then tasked with developing a POV statement for the user type they represented, which would serve as the guiding force for the design, refer to Fig. 4. It was clarified that the statement should encompass a description of the student's specific need, and the corresponding insight associated with that need. The POV statement serves as the basis for designing better solutions.

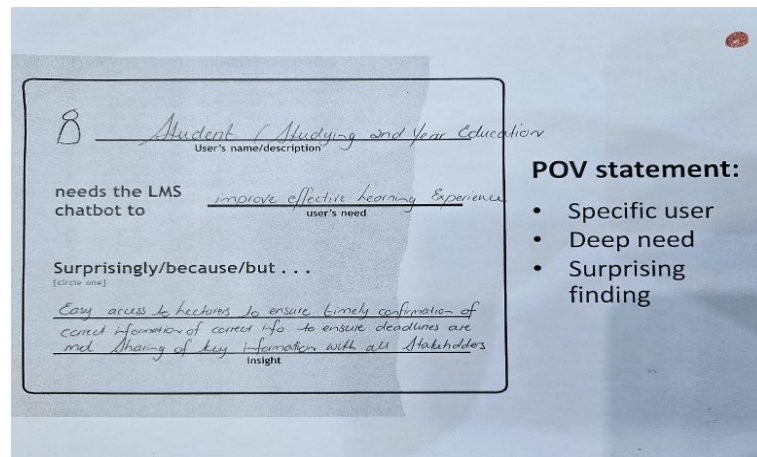


Fig. 4. Participant Worksheet: POV statement of student

Stage 3: Ideate. Once the problem was well-defined, the subsequent stage was solution "ideation," a process that challenges assumptions and generates ideas [28]. This stage involved an interactive activity, emphasising the enthusiasm of individual team members. The focus was on brainstorming around the established POV statement to address the identified needs. One effective technique for generating ideas is using "how might we" statements [29], which are focused on designing, implementing, developing, changing, or other relevant actions, e.g., "How might we find and supply academic resources?". These statements were based on insights gained from the design team members, their collaborative group work, participant worksheets, and incorporating a clear understanding of the defined problem to maximise the generation of creative ideas, striving for a broad range of potential solutions.

Subsequently, the team was encouraged to share their ideas. The ideas received from the team were then captured in Figma, providing insights to reflect upon and creatively generate new solutions. The final step involved choosing the idea with the most traction, considering it as a potential product or service and envisioning its form and function. Figure 5 illustrates the prominent ideas shared by the design team.

Stage 4: Implementation of the prototype of design principle. Once ideas are generated, they can be organised into common themes to guide the "prototyping" portion of the design thinking process. "Prototype" involves creating low-fidelity models of a proposed solution based on the ideas generated during the "ideation" stage. During the design thinking workshop, a very basic LMS chatbot prototype was created (Fig. 5.) using Figma, which provided the team with an idea of what a possible solution might look like. The team experienced this stage as fun, seeing how their contributions were visualised.

The LMS chatbot prototype was built by a postgraduate IS student, and the design teams acted as co-designers during the process. This phase allowed participants to select and develop ideas from the ideate phase that their users felt might work. The objective was to build a fast, low-cost version of the product so that, if it fails, it will

"fail fast and fail cheap" [27]. Prototyping prevents service providers from spending significant time or money on efforts that do not meet their users' needs.

Note that the LMS chatbot prototype is not considered the desired artefact of the DSR process but rather the tentative set of design principles to be discussed later. Figure 5 along with other gathered data, was utilised in the development of the tentative set of design principles. The foundational structure and the preferred layout of the chatbot were recommended and discussed in detail during the design thinking workshop. By referencing the provided Figma screenshots and consistently revisiting the audio recordings and transcripts through constant comparative analysis, the researcher gained valuable insights from the prototype, enabling a better understanding of users' preferences and expectations.

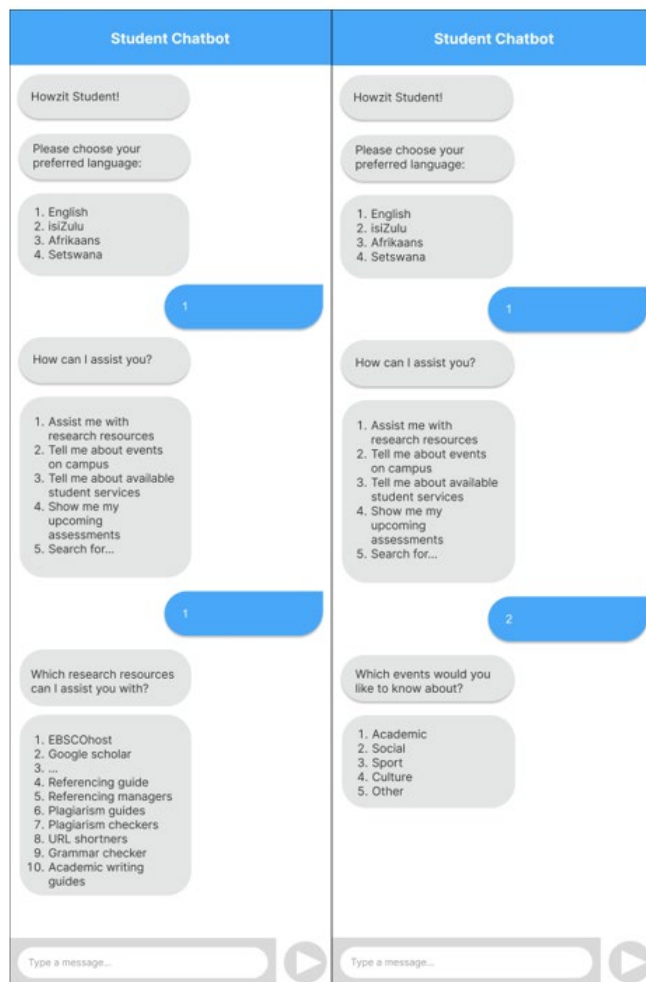


Fig. 5. Figma chatbot screenshots for students

Stage 5: Test. The design process progressed to the "test" phase, during which the researcher gained insights into user preferences and refined the prototype (a tentative set of design principles) [28]. Although the screens created in Figma were not active or integrated into an LMS, they served as a representation of LMS chatbot design principles. Informal feedback was gathered from the students during the design thinking workshop when the Figma screens were developed. This testing phase involved sharing, illustrating, and visualising user needs and preferences for the desired look and feel of an LMS chatbot.

3.2. Development of a set of tentative design principles

The culmination of the design thinking workshop yielded valuable insights that were analysed to formulate a tentative set of design principles. The data were analysed using the constant comparative method of analysis to develop the design artifact: a tentative set of design principles. The analysis was conducted with the elements of the UX honeycomb model in mind, capturing the perspective of end-users, specifying actions or tasks undertaken, identifying the goals or objectives, and detailing the challenges or needs encountered throughout the student's LMS UX. This comprehensive analysis incorporated audio-recording transcripts, observations, field notes, participant worksheets, and Figma screenshots collected during the design thinking workshop.

The ensuing examination involved a review of various elements, encompassing codes, themes, and findings extracted from the workshop. This examination included a thorough analysis of the audio recordings and participant worksheets. The resulting framework encapsulates the essence of the workshop's collaborative efforts and serves as a foundation for the development of tentative set of design principles.

Table 1. Codes and themes resulting from the design thinking workshop's audio recording

Codes	Themes
Soft tone, User-centric design, Collaboration, Interaction tools assistance, Language preference	Responsive interaction
Visual design, Emojis, Avatar, Colour, Creativity, Calendar (academic and social), User interface and design	Engaging visual elements
Different language styles, Multilingual options, Language preference	Embrace multilingual support
Third-party integration (e.g. Turnitin), Navigation assistance on campus	Seamlessly integrate into an LMS platform
Reports, Tracking, Learning analytics gap, Assessment creation, Continuous improvement	Progress tracking and recommendations
Soft tone, Emojis, Avatar	Engaging personality
Accessing resources, Calendar (academic and social), User interface and design, Academic resources, Help/assistance, Mental health	Information and resources

Design principles serve as guiding frameworks in the development of products, services, or systems, ensuring they adhere to specific criteria and objectives. Table 1 identifies recurring themes and Table 2 exemplifies how these themes correspond to the tentative set of design principles. While a direct one-to-one correlation may not always exist, the researcher established connections by recognising common themes and

conducting qualitative interpretation. This process involved employing the constant comparative method of analysis to deepen understanding and insight.

Table 2. Themes mapping against tentative set of design principles

Design Principle (DP)	Themes
DP 1: Responsive interaction	Accessibility, information access
DP 2: Focused conversation	Engagement, user-friendly interface
DP 3: Transparency on capabilities and limitations	Transparency on capabilities and limitations
DP 4: Opt-out functionality	Privacy and data security
DP 5: Appropriate tone and language	Engagement, engaging personality
DP 6: Natural language understanding	Natural language understanding
DP 7: Engaging visual elements	Engagement, interactive elements (visual elements, guidance)
DP 8: 24/7 availability	Availability
DP 9: Embrace multilingual support	Multilingual support, accessibility
DP 10: Seamless integration into an LMS platform	Management and support
DP 11: Progress tracking and recommendations	User-friendly interface, effectiveness
DP 12: Privacy and data security	Transparency on capabilities and limitations, privacy and data security
DP 13: Error handling and graceful recovery	Problem solving and feedback
DP 14: Human-agent handover	Problem solving and feedback
DP 15: Continuous improvement through feedback	Continuous improvement through feedback
DP 16: Engaging personality	Engagement
DP 17: Information and resources	Information and resources

Based on the data sets in Table 2, which included the analysis of all design thinking workshop's data, a tentative set of design principles was formulated.

3.3. Tentative set of design principles

Table 3 illustrates 17 design principles informed by the analysed data obtained during the design thinking workshop.

Table 3. Tentative set of Design Principles

Design Principle
DP1 Responsive Interaction: Create an LMS chatbot to be responsive to user input and minimise response time to optimise the UX. The chatbot should provide timely and helpful information to users, ensuring a smooth and efficient conversation.
DP2 Focused Conversation: Create an LMS chatbot that implements effective conversation management techniques to keep the conversation on topic and prevent the introduction of unnecessary information or distractions. The chatbot should maintain a coherent and purposeful conversation with users, ensuring their needs are met and queries are addressed accurately.
DP3 Transparency on Capabilities and Limitations: Create an LMS chatbot that effectively manages user expectations by clearly stating the chatbot's capabilities and limitations. The chatbot should ensure users have a clear understanding of what the chatbot can and cannot do, avoiding frustration and disappointment.
DP4 Opt-Out Functionality. Create an LMS chatbot with an easily accessible opt-out function within the chatbot's interface, granting users the freedom to end the conversation or change the topic whenever they desire. The chatbot should empower users to have control over their interactions, enhancing the UX by respecting their preferences.

DP5 Appropriate Tone and Language. Create an LMS chatbot that uses a tone aligned with the context and user preferences. The chatbot should be friendly, professional, and adaptable to different communication styles, ensuring a positive and engaging experience for users during interactions.
DP6 Natural Language Understanding (NLU). Create an LMS chatbot that employs advanced NLU techniques to comprehend and interpret user queries naturally. The chatbot should ensure more fluid and intuitive interactions, as the chatbot understands synonyms, paraphrases, and context to provide relevant and accurate responses. Implementing advanced NLU techniques is crucial for enhancing the chatbot's ability to understand and cater to user needs effectively.
DP7 Engaging Visual Elements. Create an LMS chatbot that integrates visually appealing elements, such as avatars or buttons, to enhance engagement. The chatbot should implement visual cues to assist users in understanding available options and make the conversation more interactive and visually stimulating.
DP8 Ensure 24/7 Availability. Develop a highly accessible LMS chatbot that ensures uninterrupted user support. The chatbot should incorporate redundancy measures to ensure optimal availability and minimal downtime, enabling users to access the chatbot whenever they require assistance, regardless of the time or day.
DP9 Embrace Multilingual Support. Create an LMS chatbot to cater to users who prefer interacting in different languages. The chatbot should incorporate a multilingual option in the LMS chatbot, allowing users to choose their preferred language, to enhance inclusivity.
DP10 Seamlessly Integrate into an LMS Platform. Develop a cutting-edge LMS chatbot that seamlessly integrates with the LMS platform. The chatbot should serve as a valuable addition to the existing LMS resources and tools, significantly enhancing the overall UX. Ensuring a seamless integration allows users to benefit from a cohesive and highly efficient environment.
DP11 Progress Tracking and Recommendations. Design an LMS chatbot that enhances the chatbot's ability to monitor students' progress and offer personalised recommendations based on their performance and preferences. The chatbot should help students to stay focused and continuously enhance their presence, knowledge, and skills within the LMS platform.
DP12 Privacy and Data Security. Create an LMS chatbot that adheres to data protection regulations and maintains the utmost privacy and security of user information. The chatbot should be transparent, by communicating data usage and storage policies to establish trust and confidence among users, ensuring their data is handled responsibly and securely.
DP13 Error Handling and Graceful Recovery. Design an LMS chatbot to handle misunderstandings and errors with finesse. The chatbot should provide informative error messages and suggest alternative solutions when faced with ambiguous queries. This approach ensures a seamless UX and minimises frustration during interactions with the chatbot.
DP14 Human-Agent Handover. Design an LMS chatbot to identify situations where the chatbot's capabilities may be limited and seamlessly transition to human support through an email to the service desk. The chatbot should prevent user frustration and ensures users receive the necessary assistance to overcome any challenges they encounter during their interactions with the chatbot.
DP15 Continuous Improvement through Feedback. Create an LMS chatbot that regularly gathers user feedback to identify areas for improvement and optimise performance. Utilise this feedback to iterate and enhance the chatbot's capabilities, ensuring it aligns with users' evolving needs and expectations. The chatbot should regularly seek user feedback which will assist in continuously improving the chatbot's efficiency and user satisfaction.
DP16 Engaging Personality. Create an LMS chatbot that cultivates a friendly and approachable personality to create a positive and captivating UX. The chatbot should foster a stronger connection between users, which will make the learning process more enjoyable and effective. A friendly and engaging personality helps in establishing rapport and trust, making users more comfortable interacting with the chatbot.
DP17 Information and Resources. Create an LMS chatbot that provides accurate and reliable information about mental health conditions, coping strategies, and available resources. The chatbot should link users to helpful articles, helplines, on-campus student support services, or websites as needed. This feature supports users in finding the necessary resources and support for their mental health needs.

3.4. Tentative set of design principles mapped with the UX honeycomb model

The tentative design principles can all be mapped to the facets of Peter Morville's UX Honeycomb Model (see Table 4). The mapping of the tentative set of design

principles with Peter Morville's UX Honeycomb Model provides a structured framework for understanding the significance of these principles within the context of UX design. By aligning each design principle with specific facets of UX, such as usefulness, usability, accessibility, credibility, desirability, and findability, the study highlights the holistic approach taken to enhance the overall UX of the LMS platform.

Therefore, there are no design principles in the given set that do not map to the facets of the UX Honeycomb Model. This mapping is considered valuable, firstly, because it underscores the importance of considering various dimensions of UX in the design process, ensuring that the resulting chatbot comprehensively addresses student's needs and preferences. Secondly, it facilitates a deeper understanding of how each design principle contributes to different aspects of UX, thereby emphasising their relevance and impact on user satisfaction and engagement. Furthermore, the mapping with the UX Honeycomb Model offers a systematic way to evaluate the effectiveness of the design principles in achieving the desired UX goals. By aligning with established UX frameworks, the study provided depth by illustrating how these principles address specific facets of UX, thereby reinforcing their importance and relevance in creating a user-centric, efficient, and trustworthy interaction within the LMS platform.

Table 4. Tentative set of design principles mapped with the UX Honeycomb Model

LMS chatbot design principles	UX Honeycomb Model
Responsive interaction	Useful: Ensuring that the LMS chatbot promptly responds to the user. This aligns with the usefulness aspect of UX, as users find the chatbot's responsiveness valuable in obtaining timely information and support within the LMS.
Focused conversation	Usable: Effective conversation management is crucial to maintain a conversation on the intended topic, sustaining a coherent and purposeful dialogue with users. This aligns with the usability aspect of UX, ensuring that users can easily and efficiently interact with the chatbot.
Transparency on capabilities and limitations	Credible: The chatbot's capabilities and limitations must be clearly stated to manage user expectations and contribute to the credibility of the interaction. This ensures that users trust the information provided.
Opt-out functionality	Usable: The opt-out functionality grants users control over their interactions, aligning with the usability aspect of UX by respecting user preferences. This enhances the overall usability of the chatbot.
Appropriate tone and language	Desirable: The use of appropriate tone and language contributes to a positive and engaging UX, aligning with the desirability aspect of UX.
Natural language understanding	Useful: The implementation of advanced NLU techniques enhances the chatbot's capacity to provide pertinent and accurate responses. This aligns with the usefulness aspect of UX within the LMS, as users benefit from more effective and relevant interactions.
Engaging visual elements	Desirable: Integrating visually appealing elements enhances engagement, aligning with the desirability aspect of UX. This contributes to a more enjoyable and aesthetically pleasing UX within the LMS.
Ensure 24/7 availability	Accessible: Ensuring 24/7 availability contributes to the accessibility aspect of UX, providing users with uninterrupted support whenever needed within the LMS.

Embrace multilingual support	Accessible: Offering multilingual support enhances inclusivity and accessibility, aligning with the accessibility aspect of UX within the LMS. This ensures that the diverse user base can effectively engage with the chatbot.
Seamless integration into an LMS platform	Usable: The seamless integration of the chatbot into the LMS platform elevates the overall UX, contributing to the usability aspect of UX. This fosters a cohesive and efficient environment for users within the LMS.
Progress tracking and recommendations	Useful: Progress tracking and personalised recommendations enhance the usefulness of the chatbot, helping students stay focused and continuously improve within the LMS platform.
Privacy and data security	Credible: Adhering to data protection regulations and ensuring privacy and data security contribute to the credibility aspect of UX. This establishes trust and confidence among users within the LMS.
Error handling and graceful recovery	Credible: The chatbot's ability to handle errors gracefully contributes to its credibility, minimising user frustration during interactions within the LMS.
Human-agent hand-over	Desirable: Recognising situations for human-agent handover ensures a desirable UX, providing necessary assistance when required within the LMS.
Continuous improvement through feedback	Usable: Regularly gathering user feedback and iterating based on it contributes to the usability aspect by improving efficiency and user satisfaction within the LMS.
Engaging personality	Desirable: Developing a friendly and approachable personality in the chatbot contributes to a positive and engaging UX within the LMS.
Information and resources	Useful: Creating an LMS chatbot that provides accurate, relevant and reliable information supports users in finding necessary resources, aligning with the usefulness aspect of UX within the LMS.

4. Research Findings

The findings addressed crucial aspects such as usability, desirability, accessibility, credibility, and usefulness. By ensuring responsive interaction, focused conversation, and transparency on capabilities and limitations, the chatbot promotes a usable and credible interaction with the LMS. Features like opt-out functionality, appropriate tone, and language, engaging visual elements, and 24/7 availability contribute to desirability and accessibility, enhancing user engagement and ensuring continuous support. Additionally, the principles of multilingual support, seamless integration, progress tracking [26], privacy, error handling, human-agent handover, continuous improvement, engaging personality, and information provision collectively contribute to creating a holistic UX.

The study emphasised the importance of integrating and facilitating responsive interactions within the LMS environment to address user frustrations and their strong preference for immediate and personalised support [12]. Students expect prompt responses and solutions, as well as a human touch, emotional support, and access to mental health resources. Such integration may provide students with immediate access to mental health support, bypassing constraints associated with scheduling and response times. It might also aid in destigmatising seeking help for mental health issues [31]. Students may find it more comfortable to confide in an AI-driven system than in a human due to concerns about shame or judgment [32]. However, it should be highlighted that such assistance should not replace that of a professional.

Furthermore, students have expressed the need to integrate the LMS platform with various types of software to enhance their overall LMS UX. This includes navigation aids [33] student well-being support tools, financial systems, Turnitin, academic and social announcements, campus events via a calendar feature, progress reports, grades, financial statements, proof of registration, and other relevant resources.

5. Conclusions, Limitations and Future Research

The findings contribute insights into the use of a design thinking workshop as a data collection technique in the development of LMS chatbots design principles during the development stage of DSR. Utilising the Stanford d.school five-stage design thinking process offered a structured framework for this study to enhance the LMS UX within HEIs. The mapping of the tentative set of design principles with Peter Morville's UX Honeycomb Model revealed a comprehensive alignment between the principles and key facets of the UX of the LMS.

Overall, these tentative set of design principles provide a robust foundation for the design of an LMS chatbot, promising to possibly enhance the student's overall UX within the LMS platform by creating a user-centric, efficient, and trustworthy interaction. The research aligns with the UX honeycomb and makes a significant contribution to the Information System (IS) discipline. The study further contributes to the IS discipline by providing empirically supported insights and innovative design practices for LMS. This study not only advances theoretical understanding but also provides practical utility, thereby offering a valuable contribution to the field of IS.

This study has several limitations that merit consideration. Firstly, due to the dynamic nature of the literature review, which was continuously revised and updated, the researcher acknowledges the possibility that new insights could emerge, leading to alternative views and different methodological approaches as the study progressed. Secondly, the sample group may be considered too small.

For future research, it is suggested to explore the implementation of more advanced chatbot architectures and to conduct studies with larger and more diverse samples to further validate and refine the findings of this study.

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Bridging the Gap: Towards a Hybrid Approach in Systems Analysis and Design Education

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Abstract. Information Systems Development (ISD) is a critical component of Informatics education, providing students with essential skills for designing and implementing information systems. Traditionally, ISD has been dominated by plan-driven Waterfall methodologies, such as the FAST Systems Development Life Cycle (SDLC). Agile methodologies, such as Scrum, Extreme Programming (XP), and Dynamic Systems Development Method (DSDM), prioritize adaptability, collaboration, and customer feedback over rigid planning and documentation. Hybrid approaches, which combine elements of both plan-driven and Agile methodologies, have gained traction in recent years as organizations seek to strike a balance between predictability and flexibility in software project management. This paper explores the need for a hybrid approach in systems analysis and design (SAD) education and outlines the project aims and objectives. Drawing upon insights from the literature on ISD education, ABET accreditation requirements, and ISD methodologies, we seek to identify the strengths and weaknesses of existing approaches and propose a framework for integrating Agile principles into the curriculum. By critically evaluating existing approaches through a design-based approach, using an interactive workshop of ISD lecturers, a hybrid framework informed by industry standards and educational principles is proposed. This research aims to bridge the gap between academic theory and industry practice, ensuring that graduates are well-prepared to tackle the challenges of modern information systems development.

Keywords: Information Systems Development (ISD), Systems Analysis and Design (SAD) education, Agile, Waterfall, hybrid systems development approach, capstone module.

1. Introduction and Background

Information Systems Development (ISD) is a critical component of Informatics education, providing students with essential skills for designing and implementing information systems [1]. As technology evolves and industry demands change, SAD curricula must adapt to ensure graduates are equipped with relevant knowledge and skills [2-5]. This paper examines the rationale and project description for transitioning

towards a hybrid approach in ISD education within the Department of Informatics at our institution.

Traditionally, Information Systems Development (ISD) has been dominated by plan-driven Waterfall methodologies, such as the FAST Systems Development Life Cycle (SDLC) [6]. Sequential phases characterise these methodologies from requirements gathering to implementation. However, the dynamic nature of contemporary project requirements, coupled with the need for rapid adaptation to changing business needs, has led to a shift towards more flexible and iterative approaches such as Agile and hybrid methodologies.

Agile methodologies, such as Scrum, Extreme Programming (XP), and Dynamic Systems Development Method (DSDM), prioritise adaptability, collaboration, and customer feedback over rigid planning and documentation [6]. These methodologies advocate for iterative development cycles, frequent deliveries of working software, and close collaboration between developers and stakeholders [7]. Agile approaches offer several advantages over traditional Waterfall methods, including increased responsiveness to changing requirements, improved customer satisfaction, and enhanced team morale [6].

Hybrid approaches, which combine elements of both plan-driven and Agile methodologies, have gained traction in recent years as organisations seek to strike a balance between predictability and flexibility in software project management [7]. Hybrid methodologies allow for upfront planning and documentation while also incorporating iterative development cycles and continuous feedback loops. By leveraging the strengths of both Agile and traditional approaches, hybrid methodologies offer organisations the flexibility to adapt to changing requirements while maintaining control over project scope and deliverables [8].

The move towards Agile and hybrid approaches in ISD reflects a broader industry shift towards more collaborative, adaptive, and customer-centric development practices [9]. As organisations strive to remain competitive in rapidly evolving markets, the ability to respond quickly and effectively to changing business needs has become paramount. Agile and hybrid methodologies offer organisations the flexibility and agility needed to thrive in today's dynamic business environment [10, 11].

This paper explores the need for a hybrid approach in SAD education and outlines the project aims and objectives. Drawing upon insights from the literature on ISD education, Accreditation Board of Engineering and Information Technology (ABET) accreditation requirements, and ISD methodologies, we seek to identify the strengths and weaknesses of existing approaches and propose a framework for integrating Agile principles into the curriculum.

The literature review will delve into three key areas: Teaching Information Systems Development, which examines pedagogical approaches and best practices in ISD education; ABET accreditation requirements, which outline the skills and competencies students should acquire to meet industry standards; and SAD methodologies, including Waterfall methodologies, Agile methodologies, and hybrid approaches, with a focus on their respective strengths and weaknesses.

By critically evaluating existing approaches and proposing a hybrid framework informed by industry standards and educational principles, this research aims to bridge the gap between academic theory and industry practice, ensuring that graduates are well-prepared to tackle the challenges of modern information systems development.

This study seeks to answer the primary research question: *How can a Higher Education Systems Analysis and Design curriculum be adapted to effectively integrate a hybrid methodology while ensuring alignment with industry demands and maintaining educational rigor?*

In the upcoming sections, we will first present an overview of the literature in Section 2, followed by an explanation of our research approach in Section 3. Section 4 will delve into the discussion of our data analysis and findings. Following that, Section 5 will encompass the discussion and recommendations. Lastly, Section 6 will provide concluding remarks.

2. Literature Review

The following sub-sections introduce the key aspects related to teaching information systems development (ISD) (section 2.1), the requirements for ABET (Section 2.2), Waterfall, Agile and hybrid systems development methodologies in Sections 2.3 – 2.5 respectively.

2.1. Teaching ISD

Information Systems Development (ISD) curricula at universities typically encompass a mix of theoretical foundations, practical skills development, and industry-relevant knowledge. Avison and Fitzgerald [12] give an overview of information systems development and the teaching thereof. They divide information systems development into three eras: the early methodology era (to 1988), the methodology era (to 1995), the era of methodology assessment (to 2002).

In 1988 the methodologies were simple lifecycle approaches or categorized into either data-oriented or process-oriented themes. Developers were technically trained but possessed little understanding of the organizational context, which resulted in late and over-budget systems that did not properly address the users' needs. Most courses in ISD were one-dimensional, not considering the users of the software.

During the methodology era up to 1995, information systems development matured as an academic discipline. Business process reengineering was added to the curriculum, as well as other topics such as object orientation. Many different methodologies came to light which led to a drive towards standardization.

The era of methodology assessment to 2002 saw methodologies split into different categories such as object-oriented, process, blended, rapid, people, frameworks and organizational. New methodologies included RUP and extreme programming. The consensus in the community was that productivity has not necessarily improved, methodologies are too complex and demand significant skills, require expensive tools, are inflexible, limit creativity, and provide insufficient focus. Methodologies were reappraised and some organizations moved to using a variety of approaches. There were many choices available, but organisations rarely applied a clear strategy [12].

Two decades later we observe a shift away from the highly bureaucratic types of the methodological era. Information systems development remains central to the discipline and demonstrates its value in education. Methodologies play a crucial role in training for information systems, as they teach best practice and provide a solid foundation for discussions on IS development.

To teach Information Systems Development (ISD), universities harness several pedagogical approaches and best practices. These approaches aim to equip students with the knowledge, skills, and competencies needed to effectively design, develop, and manage information systems. Examples of such approaches include Active Learning and Project-Based Learning (PBL), as well as teaching Agile methodologies. An overview of the traditional and modern SDLC models such as Waterfall, Spiral, and Agile helps students understand different approaches to ISD and their suitability for various project contexts. Because all aspects of the global computing field continue to face rapid and frequent change, Elrod, Stanley, Cudney, Hilgers, and Graham [13] call for curricula to change rapidly to stay current with industry standards, as these are an accelerating moving target. This is echoed by Baskerville, vom Brocke, Mathiassen and Scheepers [14] who agree that university-level Information Systems curricula need frequent updating to remain effective.

Universities have the freedom to tailor their curricula to reflect industry trends, technological advancements, and the specific needs and interests of their students. The Association for Computing Machinery (ACM) and the Association for Information Systems (AIS) represent the two global associations of academics in Computer Science (CS) and Information Systems (IS) respectively. The ACM and AIS's Curriculum Guidelines for Undergraduate Degree Programs in Information Systems published in 2010, and updated in 2016, defined an updated curriculum designed to educate graduates who may enter the workforce equipped with the following knowledge and skills: Foundations of Information Systems, Data and Information Management, Enterprise Architecture, IS Project Management, IT Infrastructure, Systems Analysis & Design, and IS Strategy, Management, and Acquisition.

In structuring curricula, Topi, Karsten, Brown, Carvalho, Donnellan, Shen, Tan, and Thouin [15] find that it is impossible to offer a complete collection of career-track electives, and subsequently propose that a number of elective courses are made available for students to choose from. However, they note that both Data & Information Management and Systems Analysis & Design have maintained their central roles in the core of the curriculum.

The current view on teaching ISD suggests that a balanced approach should be followed [16]. Spurrier and Topi maintain that today's reality is that a diversity of Agile, plan-driven, and hybrid approaches are widely used, with many individual organizations using multiple approaches across different projects. They concur that iterative software construction is an inherently better approach than traditional plan-driven, noniterative construction. This is because iterative construction enables frequent customer feedback and course corrections in requirements specifications during construction [17]. Therefore, Spurrier and Topi expect that modern organizations that are engaged in coding new features would move to the hybrid approach, rather than a "pure" plan-driven approach (e.g., traditional SDLC or "Waterfall"). They conclude that the real choice nowadays is between Agile and hybrid approaches to software construction, rather than Agile versus "pure" plan driven.

2.2. ABET Accreditation

The degree under consideration is accredited by ABET, a non-governmental agency that accredits programs in applied and natural sciences, computing, engineering, and technology. ABET accreditation ensures that a college or university program meets the

quality standards required by the profession for which it prepares graduates [18]. This degree is the only Informatics degree in Africa with this accreditation, making it essential for the institution to adhere to ABET's regulations while also adapting the curriculum to meet industry demands and align with future work trends. As business strategies, academic approaches, social interactions, and the future of work evolve, it is crucial to prepare student to actively participate in the industry [19-21].

According to the Criteria for Accrediting Computing Programs, 2024 - 2025, understanding ABET's student outcomes is vital for compliance with its standards and regulations. "Graduates of the program will have the ability to [22]:

- Analyse a complex computing problem and apply principles of computing and other relevant disciplines to identify solutions.
- Design, implement, and evaluate a computing-based solution to meet a given set of computing requirements in the context of the program's discipline.
- Communicate effectively in a variety of professional contexts.
- Recognize professional responsibilities and make informed judgments in computing practice based on legal and ethical principles.
- Function effectively as a member or leader of a team engaged in activities appropriate to the program's discipline.
- Support the delivery, use, and management of information systems within an information systems environment."

2.3. Waterfall methodologies

The Waterfall model is a sequential design process used in software development. It follows a step-by-step approach where progress is seen as flowing steadily downwards through several phases. These phases typically include Requirements Analysis, System Design, Implementation, Integration and Testing, Deployment, and Maintenance [23]. Each stage must be completed before the next one can start, and there is typically no overlap between the phases.

While the Waterfall model is easy to understand and often considered the preferred choice for managing complex projects, it has several notable drawbacks. Pargaonkar [24] claims that one major drawback of the Waterfall model is its difficulty in accommodating changes once a phase is completed. If a change becomes necessary in later stages, revisiting any previous stage can be challenging, time-consuming, and costly.

The Waterfall model assumes that all requirements can be gathered accurately before the design and implementation phases begin [25, 26]. However, this is often not the case as clients may not know all their needs at the outset of a project. The stakeholders and clients are only able to see a working version of the software after it has been fully developed. This leads to delayed feedback and any changes needed are only learned late in the project lifecycle. As a result, there may be dissatisfaction with delivered products [27]. Additionally, testing only occurs once the build stage is complete, and this can lead to the discovery of fundamental flaws or misalignments with user requirements late in the project. This often results in increased costs and project delays [28].

In recent times, software development teams have realised the limitations of traditional project management methodologies, which are often rigid and inflexible. To

overcome these shortcomings, modern teams have shifted towards more Agile and iterative approaches such as Agile, Scrum, or Kanban. These methodologies enable frequent reassessment of project directions and requirements and incorporate feedback at various stages of development, which ultimately leads to the development of high-quality software products.

2.4. Agile methodologies

The Agile software development methodology, characterised by its iterative and incremental approach to software development and focusing on delivering high-quality software that meets customer needs, has emerged over time [29]. This method offers a streamlined methodology designed to address the shortcomings of traditional development approaches, aiming to reduce complexity, overhead, and costs while enhancing adaptability to changing requirements by organizing and coordinating tasks according to a specific set of values and principles [30].

The Agile Manifesto, created in 2001 by a group of software developers [19], outlines the core values of Agile, emphasising the importance of flexibility, collaboration, and customer satisfaction in the software development process. These values prioritise individuals and interactions over processes and tools, working software over comprehensive documentation, customer collaboration over contract negotiation, and responding to change over following a plan [29]. Agile methodologies are driven by the need for faster delivery of software, adaptability to changing requirements, and continuous customer feedback [20]. By breaking down projects into small, manageable tasks and delivering working software in short iterations, Agile enables teams to respond quickly to changing market conditions and customer needs [21].

The utilisation and implication of the Agile methodology have been reported in diverse domains, including Human resource management [31], marketing [32], product development [33], and manufacturing [34] to mention just a few. The Agile values are still relevant in this time and age and popularly adopted after its proclamation over two decades ago [35]. Despite its wide adoption, Agile may not be the most suitable approach for every project due to factors such as the project size and complexity [36], resistance to change [37], quality assurance requirements [38] and team experience [38].

In such cases, a hybrid methodology that combines Agile principles with elements of more traditional project management approaches, such as Waterfall, may be more suitable. A hybrid approach allows for greater flexibility and adaptability than traditional methods while still providing the structure and documentation required for large, complex projects. Agile methodologies have transformed software development by emphasizing flexibility, collaboration, and customer satisfaction, and while Agile may not be suitable for every project, its principles can be adapted and combined with other approaches to create a hybrid methodology that meets the unique needs of each project.

2.5. Hybrid systems development approach

Although different systems development approaches have evolved since the 1970s, organizations in practice rarely strictly adhere to a single specific methodology [9]. As such, it is not uncommon for organizations to combine practices from different

methodologies into their development context [9, 11]. Consequently, the hybrid approach is increasingly being adopted by many organisations [9]. Hybrid software development can be described as the combination of practices, methods and tools from different methodologies to meet the specific needs of an organisation [9, 11]. There are three generic approaches to the use of hybrid methodology. This includes:

1. The Waterfall-Agile (WAM) approach has the phased structure in the Waterfall model as its foundation but is integrated with the iterative development of the Agile approach [9, 11]. This approach can also take the form of blending a little bit of upfront planning that is characteristic of the Waterfall methodology with iterative development [39, 40].
2. The Waterfall-Iterative (Waterative) approach has the iterative methodology as its foundation but within each iteration, the Waterfall phase model is used [9, 11].
3. The Pipeline Method (PM) is based on the parallel execution of Waterfall phases for different software increments [9, 11].

A hybrid software development approach allows organisations to offset the drawbacks associated with exclusive use of either the Waterfall or Agile methodology, while taking advantage of their benefits [41]. For example, Agile methodologies are often criticised for their lack of structure, documentation, and predictability. The traditional Waterfall approach lacks flexibility and the speed to adapt to changing business requirements [42, 43]. In a study by Imani et al. [42], the authors found that the hybrid software development approach can scale well in projects with high levels of requirement uncertainties. In addition, the hybrid method has the potential to improve the software project success rate. Previous studies have also shown that the hybrid approach is becoming the norm across different industry sectors, irrespective of company size [43, 44].

Despite the highlighted benefits, the hybrid approach is not without challenges. Some of these challenges emanate from conflicts between the fundamental principles that form the foundation of the Waterfall and Agile methodologies. In a systematic mapping study conducted by Prenner et al. [11], the authors found that the commonly reported challenges associated with the hybrid approach include the following:

- Changing high-level requirements requires significant effort to update all related documents for consistency.
- There is a conflict between upfront requirement specification and continuous requirements engineering, making it hard to balance initial analysis effort with the detail needed. Uncertainties in upfront specifications and incremental requirements may not lead to optimal solutions.
- There can be a conflict between the explicit documentation and strict compliance of the Waterfall model and the reliance on tacit knowledge in Agile, which speeds up development.
- Balancing centralized decision-making for change requests and the mutual adjustment in self-organized teams can be difficult and chaotic with too many participants involved.

For these challenges to be overcome and to maximize the benefits of the Agile approach, compromises must be found between the areas of conflict.

4. Methodology

The research project employed a design-based research approach, aimed at enhancing educational practices through iterative analysis, design, development, and implementation of improvements in collaboration with researchers and practitioners in real-world settings [45]. Design-based research is regarded as pragmatic, as it addresses real-life problems within their actual context, and is interactive and iterative through ongoing collaboration between researchers and practitioners. It is also integrative by employing diverse approaches, and contextual by connecting results to the development process and research setting [46].

Seven lecturers from the first, second, and third-year lecturing teams participated in an interactive workshop aimed at identifying shortcomings in the current framework. Qualitative data was collected, focusing on eliciting detailed descriptions and experiences from the lecturers. The following section reports the identified shortcomings in the current methodology.

5. Data Analysis and Findings

The content and presentation methods used throughout the previous Waterfall methodology, as well as the content and presentation using the newly suggested framework, are described in the parts that follow as an outline of the material taught over the course of three years. **Fig. 1** shows the topics covered per year.

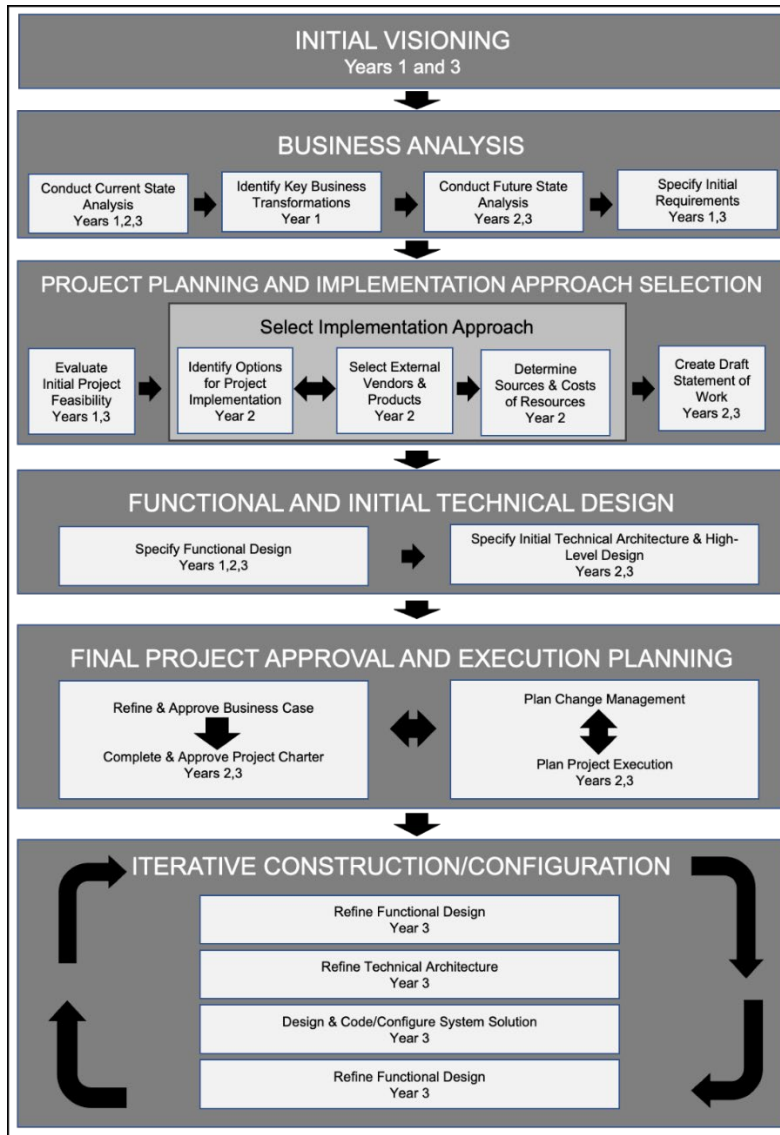


Fig. 1. ISD content mapping to new suggested framework (Adapted from Spurier and Topi [40])

5.1. Year 1

In a year-long course, first-year students are introduced to the concepts of information systems, systems thinking, creative problem solving, business processes, systems life cycle methodologies, and systems design modeling diagrams at a logical level. This includes use case diagrams, use case narratives, structured process modeling, and data modeling. These concepts are assessed using a small case study.

Following the implementation of the new framework, none of the content aspects of this course changed. However as illustrated in Fig. 1, the content was grouped to lead

to the understanding of the initial visioning of an information system, the current and future state of a system, and the functional specification design of a proposed system.

5.2 Year 2

In a year-long course, second year students build on the knowledge of the first year. In addition to recapping functional design techniques, students are taught project management aspects, the use of a project management tool (such as MS Project or ASANA), technical process modelling, technical data modeling, object-oriented modeling, and input and output design. Following a structured systems development methodology, students are required to analyze and design a solution for a given mini case study. They are consequently required to deliver four project deliverables in teams of five:

- Deliverable 1: A project proposal detailing the business case with a complete set of functional and non-functional requirements.
- Deliverable 2: A functional requirement specification detailing the logical analysis of the business represented in the mini-case study using logical models to present functional requirements and the data needed to fulfill the requirements as set out in the solution proposal.
- Deliverable 3: A complete prototype design detailing the screens and outputs for each requirement.
- Deliverable 4: A technical specification detailing the technical design of the requirements using technical models (either technical structured models or UML models) that add the technology required to implement the different functional requirements.

Following the implementation of the new framework, these aspects are still being addressed under the business analysis, project planning and implementation approach selection, functional and initial technical design and final project approval and execution planning.

5.3 Year 3 (Capstone Project)

Final-year capstone students are required to develop an end-to-end software solution for a real-life client in ten months, from February to November. In teams of five, they must identify and approach a real-life client, learn about the client's business context and problems, and design and develop a turnkey solution based on their investigations. The project is delivered over ten months, with eleven deliverables marked in six respective marking sessions. During the marking session, teams present their deliverable and are assessed by two lecturers based on their presentation, submitted work, and project management abilities (completed in a project management tool such as MS Project or ASANA). Each deliverable has different weightings, and all information is provided to the students at the beginning of the year in the study guide. If students have not mastered a necessary concept, consultation with lecturers and assistant lecturers is available. A brief recap of concepts is presented by the course coordinator before each deliverable, but students are generally required to self-study to grasp the needed concepts. A formal process exists to "remove" underperforming students, who must either complete the project themselves with a reduced scope

(approved by the course coordinator) or return the following year with a new team and project.

Students deliver the following deliverables sequentially from March to October:

- Deliverables 1 – 4: Identical to those completed in the second year of study, completed from March to July.
- Deliverable 5: Internally tested system, completed in September. The complete system is tested against the requirements identified and designed in deliverables 1 - 4.
- Deliverables 6 and 7: System documentation and project repository, completed in September.
- Deliverable 8: Tested System and project examination, where the complete system is tested against the requirements identified and designed in deliverables 1 - 4, incorporating feedback from deliverable 5.
- Deliverables 9 and 10: User documentation and project video, including a user manual, training manual and system use video.
- Deliverable 11: Project Day, exhibiting the system to external stakeholders.

The deliverables follow a FAST Systems Development Life Cycle (SDLC) approach up to deployment (support and maintenance are not part of the module's scope). Although some systems are deployed, not all are implemented by the clients, though all implementation documentation is completed. This approach exposed students to all SDLC activities but had the following drawbacks:

- Industry adopts more Agile approaches.
- Industry research revealed a majority favor UML modelling approaches over structured analysis.
- In FAST SDLC approach, requirements are revised as students' understanding of the system grows.
- Programming needs to start earlier to give teams more time to develop systems.

In response to the challenges, lecturers implemented a hybrid Agile approach. They recognized that the industry requires a combination of structured approaches and UML modelling and acknowledged that some students might lack the programming skills for strict Agile methodologies. Therefore, they adapted the FAST SDLC approach as follows:

- Iteration 1: Proposal Development, as per Deliverable 1
- Iteration 2: Initial functional requirements, including use case diagrams, conceptual data modelling, and domain class diagram.
- Iteration 3: Initial technical specifications, including the technology to be used in implementation, technical data model, and SQL script for the database.
- Iteration 4 – 6: Functional and technical design and development of selected requirements. Iteration 4, which presented the first design and development of selected requirements, with the first design and development iteration due in May, bringing programming forward by three months.

- Iteration 7: Internally tested system, as per Deliverable 5, complete system design documentation incorporating feedback received from previous iterations, and project repository, assessed in September.
- Iteration 8 and 9: As per Deliverables 8 – 11, assessed in October.

The iterations used JIRA for project planning and GitHub Classroom for collaborative programming. This hybrid approach was implemented for two years, with the following observations:

- Close alignment is necessary between iteration timelines and the programming module schedule, with challenges observed in the first year corrected in the second year.
- Starting programming earlier allows weaker teams more time to improve on their programming skills.
- The new hybrid approach was not grounded in any theoretical framework.
- The new hybrid approach caused misalignment between the first/second- and third-year implementation methods.

The hybrid approach framework presented by Spurrier and Topi [47] provided structure but required adjustments in how the iterations were completed. As shown in **Fig. 1**, the “new hybrid approach” described above needed the following changes:

- Iteration 2: Requires the complete functional design specification and the initial technical specification, detailing research on possible technological solutions for the proposed system.
- Iteration 3: Requires the final project approval and execution planning, using a recognized approach such as impact mapping or use case dependency diagram to prioritize use cases for development and assign the scope of work for the next iteration to team members.
- Iterations 4 – 9: Remain unchanged.

6. Discussion and Recommendations

To effectively evaluate the potential of the Spurrier and Topi hybrid framework [47] it is proposed to initiate a pilot study within selected courses. This pilot will enable real-time adjustments based on direct classroom experiences and industry feedback before broader curriculum integration. The current framework lacks detailed methodologies; thus, integrating Agile project management tools such as Scrum and software design techniques like UML diagrams is essential. These tools will bridge the gap between theoretical knowledge and practical application, thereby enhancing student preparedness for professional environments.

Additionally, establishing robust partnerships with local IT companies is crucial. These collaborations should include guest lectures, internships, and live project opportunities, providing continuous industry feedback and enriching the educational experience. To ensure the curriculum's effectiveness and relevance, a comprehensive evaluation plan using both qualitative and quantitative methods will be implemented. Regular analyses of feedback from students and faculty, along with performance metrics, will guide ongoing curriculum refinements.

Adapting the framework to address the specific challenges and opportunities of the South African IT landscape is also vital. Incorporating local industry case studies and addressing unique regional challenges will enhance the framework's relevance and effectiveness. This localization ensures that graduates are well-prepared to contribute effectively both locally and globally.

Fig. 1 illustrates the first instantiation of the Spurrier and Topi hybrid approach framework [47] demonstrating how initial understanding of the business environment, business processes, and problem-solving techniques are integrated at the beginning of an ISD project. The curriculum is structured to build upon this foundation with scaffolded content across three years, culminating in the capstone project. This content spans business analysis, project management, and both functional and technical design. This approach not only aligns with the industry's need for agility in system design but also accommodates the educational environment where students' skills are still being developed.

These strategic enhancements aim to not only respond to industry trends and technological advancements but also provide a robust framework where theoretical knowledge is seamlessly integrated with practical skills. This holistic approach prepares students effectively for the dynamic demands of modern IT environments, ensuring they are competitive and competent in their future careers.

7. Conclusions

The initial phase of our study focused on evaluating the suitability of the proposed hybrid framework by Spurrier and Topi [47], identifying and addressing the shortcomings in the current methodologies employed during the first two years and in the capstone module of our ISD curriculum. This assessment revealed that the hybrid approach is well-suited to addressing these deficiencies, providing a robust foundation for revising our curriculum.

In Phase 2, our research will concentrate on refining the undergraduate ISD curriculum to fully integrate the Spurrier and Topi framework across all three academic years. This integration will include a detailed implementation strategy, specifying the techniques and tools necessary to facilitate the adoption of the framework's components throughout the curriculum. By incorporating Agile project management tools such as Scrum and software design techniques like UML diagrams, we aim to bridge the gap between theoretical knowledge and practical application.

To ensure the curriculum meets industry demands, we will establish robust partnerships with local IT companies. These collaborations will provide guest lectures, internships, and live project opportunities, offering continuous industry feedback and enriching the educational experience. Furthermore, adapting the framework to address specific challenges and opportunities within the South African IT landscape will enhance its relevance and effectiveness, ensuring graduates are well-prepared for both local and global industry requirements.

Our ultimate objective is to align our curriculum with the IS2020 Competency Model [15, 48] for Undergraduate Programs in Information Systems. This alignment will enhance our program's relevance by incorporating varied systems development methodologies and modelling tools, including object-oriented methods, the software development life cycle (SDLC), and Agile software development techniques. It will

also ensure that our graduates are well-prepared to meet the demands of the modern IT industry.

By adopting this comprehensive approach, we aim to foster a more dynamic and responsive educational environment. This study underscores the viability of hybrid methodologies in academic settings and highlights the necessity for continuous curriculum assessment and adaptation in response to industry advancements and educational standards.

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Balancing Acts: Reflecting on the Workload and Academic Burnout in Software Development Project-Based Learning Modules vs. Traditional Modules

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Abstract. This study explores academic burnout among lecturers, which is a significant concern in higher education, particularly in modules involving project-based learning (PBL) compared to traditional modules. The focus of the study is on examining the opinions and reflections of four lecturers within an IT department at a regional university who have extensive experience in both traditional module teaching and software development PBL modules. By conducting semi-structured interviews, the study attempted to understand the insights and perceptions into the comparative workload between traditional modules and PBL modules and the level of burnout associated with and compared between delivering these types of modules. The interview questions were used to evaluate both the workload and extent of burnout experienced by the lecturers delivering these modules. This approach allowed the capture of responses that reflect the interplay between lecturing responsibilities and lecturer well-being. While this study does not aim to draw any conclusions concerning the causes of academic burnout, it contributes to the ongoing discussion by highlighting how delivering different types of modules impacts lecturer fatigue and stress. The discussions found in this study provide a starting point for further investigations that might result in managing workload and reducing burnout among academics, especially those lecturing software development PBL modules.

Keywords: Academic Burnout, Project-based learning modules, Software Development, Traditional Modules.

1. Introduction

In the evolving landscape of higher education, the difference between traditional modules and project-based learning (PBL) modules has emerged as a focal point in the analysis of educational methodologies. Traditional modules are characterised by a structured approach, typically involving lectures, fixed syllabus, and examinations that

aim to measure knowledge acquisition in a controlled, predictable manner. This type of module is more based on direct education and frequently places more emphasis on theoretical knowledge than on real-world applications [1, 2].

PBL modules, on the other hand, combine and integrate the academic program learning objectives into a single coherent project. These projects, especially in the context of software development, enable students to work with real-world issues and create solutions that include their accumulated learning from a variety of modules. This approach encourages students to go from theoretical frameworks to real-world applications and requires more flexibility and problem-solving abilities from lecturers as well as students [3]. Unlike traditional modules, PBL modules in software development are less predictable and require continuous dynamic engagement from lecturers, often blurring the lines between teaching, mentoring, and collaborating.

However, lecturers are frequently faced with a more demanding and intricate task while delivering PBL modules. They are required to provide comprehensive guidance and feedback, customise learning opportunities, and frequently take on many different roles such as mentors, supervisors, and collaborators. These demanding tasks have the potential to increase stress levels among lecturers and cause academic burnout. In addition to the high levels of uncertainty and frequent student interactions involved in PBL, other factors contribute to academic burnout in lecturers which include work-life imbalance, a lack of institutional support, and the quick adoption of new technologies in the classroom. All these factors require ongoing adaption, which can be difficult and time-consuming [4, 5, 6].

This extent of workload is mostly overlooked, and very little research has been conducted regarding the workload and academic burnout amongst PBL module lecturers as compared to traditional module lecturing, especially in software development courses.

Therefore, this paper aims to explore and reflect on the workload differences between traditional modules and PBL modules in software development, and to examine the implications of this workload on academic burnout among lecturers. By identifying the specific demands placed on staff in different teaching contexts, this study seeks to contribute to the development of strategies to alleviate stress and prevent academic burnout, ultimately enhancing the effectiveness of educational delivery and improving the overall quality of higher education. This research underscores the need for higher educational institutions to recognise and adapt to the evolving demands of educational delivery, ensuring that lecturers are supported and that educational outcomes are maximised.

1.1. Research Problem

Software development lecturers have specific challenges within different teaching modes, especially between traditional modules and PBL modules. These types of module approaches may have an impact on lecturers' workload as well as contribute to academic burnout. Limited research has been done to determine how these various teaching methods impact the stress levels and work satisfaction of lecturers in software development. This gap in knowledge hinders the development of effective strategies to mitigate burnout and maximise teaching efficiency in higher education. This study aims to address this gap by comparing the impact of PBL versus traditional learning methods on workload and burnout among software development lecturers.

1.2. Research Objective

The primary objective of this study is to assess and compare the workload associated with lecturing PBL software development modules to that of traditional modules among software development lecturers. Additionally, this study evaluates the level of burnout experienced by software development PBL module lecturers in relation to lecturing these types of modules and gathers reflective insights on the challenges of their respective modules.

This paper is structured as follows. Section 2 provides related literature regarding academic burnout in PBL lecturing compared to traditional lecture-based modules. Section 3 discusses the research methodology undertaken in this study, with a key focus on the semi-structured interviews conducted. Section 4 discusses the results and findings before Section 5 concludes the paper.

2. Literature review

PBL modules necessitate a dynamic and unpredictable commitment from lecturers since they synthesise learning objectives through practical application. In terms of workload and student involvement, traditional lecture-based modules are usually more organised and predictable, which creates a stark contrast to PBL modules [7]. The role of the lecturer is ever-changing as the educational landscape moves towards more technologically advanced and collaborative settings, necessitating constant innovation and adaptation.

Understanding the effects of these intense educational programs requires an understanding of the concept of lecturer academic burnout. Academic burnout can present itself as emotional exhaustion, depersonalisation, and a decline in professional efficacy, along with cognitive weariness and erosion in personal values [4, 8]. PBL demanding requirements for emotional support and mentorship can leave educators under more stress, which may eventually result in burnout. Especially in settings where lecturers are always under consistent pressure to adjust to new teaching approaches, oversee larger classes and fulfil rising academic requirements all while balancing their personal and professional lives.

Maslach [9] defines burnout as a psychiatric condition resulting from ongoing professional stress that has not been effectively controlled. Burnout is primarily caused by mismatches in several areas, including workload, control, reward, community, justice, and values. This knowledge is essential for academic settings since mismatches of this kind can negatively affect lecturers, impairing their productivity and decreasing their sense of fulfilment in their work [9].

IT lecturers face unique challenges due to the need for constant innovation and rapid adaptation to new technologies in their field. The lack of professional autonomy and the emotional toll of maintaining deep and sustained engagement with students in such dynamic environments can further intensify stress levels. Moreover, the push towards digital transformation in education not only introduces new tools but also demands that lecturers in software development quickly adapt to changing technological interfaces and evolving student expectations, which can be both taxing and time-consuming [10].

Studies highlight the relationship between lecturer well-being and student results, showing how lecturers' mental health affects their efficacy and, in turn, students' achievement [11]. Moreover, it has been demonstrated that the inclusion of

multidisciplinary projects in software development modules increases concerns about workload, emphasising the necessity for lecturer collaboration and careful workload distribution [5, 12]

These findings imply that although PBL and modules under proper supervision have many positive educational effects, they further add pressure and expectations on the lecturer. In addition to encouraging greater academic accomplishment among a variety of student groups, effective PBL in software development may reduce academic burnout by fostering more stimulating and rewarding lecturing environments. However, maintaining this balance calls for the development of supportive systems that mitigate academic burnout among lecturers and guarantee the continuation of effective lecturing methods [2].

The extent of academic burnout and workload experienced by lecturers in PBL modules compared to traditional modules is often not fully understood. This disparity emphasizes the necessity of exploring, through reflection, the causes and contributing factors of academic burnout in PBL environments. This kind of research is essential for equipping management to improve support to avoid burnout for lecturers successfully.

3. Research Methodology

This study focused on the insights and reflections from four participants within an IT department at a regional university in South Africa with extensive experience delivering software development PBL modules and traditional modules. These participants have been selected based on their active engagement with PBL teaching methods and their willingness to contribute reflective narratives for this study. Primary data was collected through semi-structured interviews that captured the participants' experience and reflections on delivering PBL software development modules compared to traditional modules and the extent to which they felt academic burnout between these types of modules.

The interview questions were designed to evaluate various aspects of module delivery and module management, as well as the various dimensions of burnout within delivering these modules. Each lecturer contributed based on their experiences with PBL and traditional modules. They were asked to reflect on their workload in PBL modules as compared to traditional ones. Furthermore, lecturers were then asked to reflect on the level of burnout they had experienced from delivering PBL modules and reflect on the various causes and factors contributing to their academic burnout.

The questions encouraged the lecturers to consider several key points when reflecting on their experiences. They were asked to recall specific instances that shaped their views on the workload associated with both traditional and PBL modules, discuss any strategies they have implemented to manage this workload and express their overall satisfaction with the teaching and learning process between each module type. The personal insights were analysed to better understand the workload implications associated with different teaching modules and their relation to academic burnout among lecturers delivering PBL modules.

The interviews were structured to gather data about the lecturers' backgrounds, perceptions of workload and burnout, and suggestions for mitigating problems associated with workload and burnout.

2.1. Background

The initial part of the interview was used to establish the years of experience of each of the participants in teaching software development PBL modules, as well as the support received by the lecturer. It included the following questions:

- Please specify the years during which you lectured the software development PBL module and which academic qualification it was associated with.
- Please provide the approximate number of project groups you supervised per year and the minimum, along with the maximum, number of students per group.
- Did you receive any form of assistance, if so, what type of assistance (e.g., supervisory support, marking assistance, presentation judging panels, technical guidance)? Please elaborate.
- What type of systems (e.g., desktop, web-based, mobile apps) did students have to develop? Were the students given the project specifications (generic projects) or did they have to come up with their own project ideas? Please elaborate.
- What type of deliverables did the groups have to deliver? Please elaborate.
- Can you describe the structure and management of the project (e.g., number of iterations, assessment criteria, judging sessions)? Please elaborate.
- Are there any additional insights or unique experiences you encountered while lecturing the PBL module that could provide valuable context?

2.2. Workload

This part of the interview focused on gathering the participants' perceptions of workload. Specifically, the goal was to gauge how the participants perceived the difference in workload between a traditional, test and assignment-driven module and a PBL one.

They were asked to indicate their perceptions regarding the following:

- Lectures – Preparation: Preparing slides to present lectures. Preparing handouts and other relevant documents that will be provided to students.
- Lectures – Execution: The actual presentation of a lecture, tutorial, practical, JAD session, etc.
- Assessments – Development: Developing question papers, templates, rubrics, and other documents that will be used to assess students. Arranging invigilators, a judging panel, moderators and any other assistance that will be required to assess students.
- Assessments – Executing: The actual effort/time it takes to assess the students, for example, the test duration compared to the duration of a project judging session.
- Assessments – Marking: The effort/time it takes to mark assessments. Some of this marking may occur during judging sessions.
- Consultation with students: The effort/time it takes to consult with individual students and/or groups.
- Administration: The effort/time it takes to manage the module. This includes capturing marks, collating marks from multiple markers, calculating final

marks, scheduling meetings, and any other administration involved with managing the module.

2.3. Burnout

The next part of the interview focused on determining whether the participants were feeling (at least according to their own perceptions) the effects of burnout. It should be noted that these questions were asked under the assumption that participants are aware of what burnout is.

Participants were asked to share their perceptions regarding possible burnout experienced while offering a software development PBL module compared to a traditional module. They were asked whether they experienced any of the following dimensions of burnout [4, 9]:

- Emotional Exhaustion: Feeling drained, tired, and lacking energy to face one's workday.
- Depersonalisation: Developing a cynical or detached attitude towards one's job and the people involved with it.
- Decline in Professional Efficacy: Experiencing a sense of ineffectiveness and a lack of accomplishment at work. This dimension reflects a feeling of inefficiency and a decline in one's confidence in their ability to perform their job successfully.
- Cognitive Weariness: This includes difficulty in concentrating, decreased cognitive flexibility, and lowered problem-solving capacity.
- Erosion of Personal Values: Burnout can cause individuals to question or deprioritise their personal values that may have once been closely aligned with their professional roles.

2.4. Suggestions to mitigate workload and burnout.

Lastly, participants were asked to discuss any measures that they have put in place to manage the workload and/or burnout associated with offering a software development PBL module, from small changes to larger changes, such as changing the way the project is run compared to previous years.

3. Research Findings

3.1. Background of Participants

The participants in this study were all project coordinators for software development PBL modules between 2018 and 2024. These PBL modules were offered as final year modules in the National Diploma Software Development (NDip), Bachelor of Technology in IT (BTech), Bachelors in IT (BIT), and Advanced Diploma in IT qualifications within the School of IT at the university at which the study was conducted. The number of individual projects that had to be managed per year ranged from as little as 10 groups in the BIT to as many as 86 groups in the Advanced Diploma. Group sizes ranged from 1 to a maximum of 4 students per group. BTech and BIT projects were not generic and could be desktop, web-, mobile-based, or a combination of these. NDip and Advanced Diploma projects were all web-based generic projects given to groups. The generic nature of the project was due to the large number of groups that had to be accommodated.

Except for the BTech projects, no project supervisors were involved and the lecturer responsible for the module had to be both project coordinator and supervisor for all groups. For the BTech projects, each student was assigned a supervisor from amongst the staff in the School of IT. Although NDip project groups historically had project supervisors assigned from amongst staff, this arrangement had fallen away in recent years due to a lack of staff capacity and a growing number of project groups. Project groups thus had to rely on the lecturer responsible for the module for individual feedback. Groups also received limited technical assistance with their projects from technical staff in the School of IT, which has declined in recent years. Support to the lecturer responsible for the module was mainly provided through selected staff members who were able to assist in marking/judging project presentations. In some cases, master's degree students were appointed to assist students with technical issues in their projects.

Project deliverables included technical documentation with varying content and a fully functional system. Groups were also expected to present their projects. Presentation modes ranged from in-person presentations to online presentations to pre-recorded videos. The PBL modules were all presented as continuous evaluation modules with several assessment opportunities spread throughout the academic year.

3.2. Workload

The participants shared their perceptions regarding the workload associated with a software development PBL module compared to a traditional module. These perceptions are discussed in this section.

Preparing for and delivering a PBL module is, in many cases, less of a burden than with a traditional module. The lectures for PBL modules are more conceptual and provide an overview of requirements and examples of acceptable solutions. This contrasts with a traditional module, which focuses on specific concrete skills by going through a predetermined set of topics the students need to master. Lectures in PBL modules tend to assume the underlying skills and take the shape of guidance on how to combine or deliver the outputs by using these skills.

PBL modules typically go through several annual assessment cycles, typically called iterations. Developing assessment opportunities may require less effort/time since there is no memorandum to set as with a traditional module assessment. A marking rubric with different criteria across the systems development lifecycle (SDLC) is typically developed to assess project deliverables. On the other hand, the evaluation of the project deliverables is a much more involved process requiring significantly more effort and time. Each deliverable requires considerable scrutiny and involves the creation of formative feedback, which the students can use to improve their final deliverables at the end of the year or semester. This contrasts with marking tests or exams typically associated with traditional module assessments.

Another assessment aspect of a PBL module that differs from a traditional one is that projects tend to have judging sessions multiple times a year, which stretch over multiple days, and for cases with many project groups, it could extend into weeks. This is not something that has a direct equivalent in a traditional module. Thus, it is not surprising that all participants rated the time and effort required to execute and mark assessments for PBL modules significantly more than traditional ones.

Because projects are open to change, students submit constant revisions of deliverables. This greatly increases the lecturer's workload because they must offer feedback on these revised submissions. Meetings with every group are important but challenging in terms of workload, considering that there were as many as 86 project groups for some PBL modules. The hands-on contact with students in a PBL module is also much more involved as lecturers are each project group's project coordinator and supervisor. Project groups are required to have multiple meetings per term with their supervisor. In recent years the project lecturer is expected to act as supervisor for all project groups in their PBL module, even providing technical assistance due to the shortage of technical assistance. Each project meeting with a project group typically takes at least a minimum of half an hour, drastically increasing their workload, which is not necessarily reflected when the university's workload calculation is done. Officially, the workload calculation shows that it is a single module with one double lecture period per week, but this does not reflect the actual situation. All these mandated hours of extra meetings and judging are usually not considered and are challenging to plan for as they vary depending on the number of students/groups per year. Departmental management needs to consider all the aspects of facilitating a PBL module when it comes to workload allocation for staff members involved. The participants thus rated the effort/time associated with PBL modules significantly more than a traditional module.

Some administrative aspects related to PBL module workload are relatively the same as a traditional module. The PBL module does have an increased workload in terms of organising students into groups at the beginning of the academic year (if relevant), arranging venues for judging sessions, identifying available judges, and so forth. Moderation of a continuous assessment PBL module is also more complex than the moderation associated with a traditional module. With a traditional module, the lecturer typically must only arrange to moderate one exam. With a PBL module, it is necessary to arrange for a moderator to moderate various assessment opportunities throughout the year, which often requires the moderator to attend judging sessions.

The general increased workload associated with PBL modules may lead to burnout among lecturers. In the next section, perceptions regarding possible burnout when lecturing a PBL module are explored.

3.3. Burnout

The participants shared their perceptions of possible burnout associated with a software development PBL module compared to a traditional one. They were asked to indicate how likely they were to experience the various dimensions of burnout when offering a PBL module compared to a traditional module.

Before addressing the issue of burnout within PBL modules, it is important to reflect on the changes in PBL modules in recent years. There has been a significant increase in students, partly due to accommodating students who failed the previous year, leading to significant challenges. In the past, project lecturers had the support of other School of IT staff members providing supervisory support to project groups. This is no longer the case, due to a significant increase in student numbers and an associated decrease in staff capacity to take on the additional responsibility of acting as a project supervisor. It is now the sole responsibility of the project lecturer to provide supervisory support to as many as 86 project groups. Project lecturers were previously only responsible for

coordinating, supervising some groups and assessing the module. Project supervisors were often involved in the assessment of their groups as well. Currently, the project lecturer must coordinate, assess, and supervise all project groups with little to no assistance.

The increased workload leads to increased burnout among project lecturers. The perceived burnout is worsened by a lack of recognition regarding the increased workload associated with PBL modules compared to traditional modules. It seems that academic burnout is strongly affected by a mismatch with management and/or policy, which causes undue stress in the employee. This may result in a previously well-performing lecturer exhibiting a health decline, missing more and more days from work and decreasing their productivity, resulting in a vicious circle of more stress as the student numbers increase each year. Management often does not realise the extra effort it takes to offer a software development PBL module as the increased workload is not recognised in the workload model calculations. Knowing that management acknowledges the amount of work that goes beyond a double lecture period on the timetable each week and allowing project lecturers to manage their time more efficiently could ease some of the effects of burnout.

The effects of burnout due to increased workload amongst project lecturers can be recognised when considering the statements by some of the participants:

“My own cognitive capacity has clearly decreased due to these difficulties. This excessive workload directly prevents me from thinking critically and engaging with my work to the fullest extent possible.”

“There simply is no time to rest on any level – mentally, emotionally, and physically. It ends up feeling like you have so much to do and insufficient time.”

Over the last few years, the participants have devised innovative measures to mitigate the increased workload and try to prevent burnout. In the next section, some of these measures are discussed, along with other suggestions that project lecturers could consider to ease the effects of increased workload and associated burnout.

3.4. The Balancing Act

Some of the innovative measures employed by participants lecturing large cohorts of PBL module students include assigning a specified generic project to the entire cohort. This eases the workload regarding Joint Application Development (JAD) sessions, supervisory support, and feedback. Where students were previously allowed to supply their own project ideas, assigning the same generic project to the entire cohort goes a long way towards decreasing the lecturer's workload. When assigning the same project to all, further measures could be employed to further decrease the workload, such as:

- Providing test data that should be pre-loaded into the project database before an assessment. When presenting the system's functionality, the assessor thus knows what to expect in terms of the data displayed.
- Further to the above, specific scenarios could then be provided for students to present when showcasing the functionality of their system. The assessors would then know what the expected system response should be in certain pre-defined scenarios, and it is thus easier to identify problems with how the functionality

was developed. Due to the preloaded data in the database, such scenarios could be very specific, for example, instructing the student to log in as a specific user and perform a specific task with provided parameters.

The remainder of this section discusses further suggestions to alleviate problems related to increased workload and the associated burnout. One of the key factors in alleviating or trying to prevent burnout is a work-life balance and supportive environment. The supportive environment at work is never really within the control of the lecturer and might be difficult to attain in an environment filled with other individuals who are experiencing the same symptoms because of the same organisational strategies, policies and management styles. A work-life balance is something that is within the control of individual lecturers to a greater extent. Small steps such as turning off email and team notifications after hours and doing some form of exercise daily makes a big difference in how you tackle your day and how you feel about the challenges it may bring.

Management needs to realise how much extra effort it takes to run a PBL module and needs to bring this into calculation in the workload model. One way to address this is to officially allocate a few venue-less practical periods to the lecturer per week to compensate for the large number of consultation sessions the lecturer needs to schedule, which are typically not reflected on the timetable and thus not accounted for. A simple calculation, such as 30 minutes for each group every second week, can be used to estimate the number of practical periods required weekly to represent the number of project group consultation sessions the lecturer has every week.

A process of student peer review could be implemented. One of the soft skills that students lack is critically reviewing and/or assessing the work of others. Working through peers' work may help improve students' skills, allowing them to think of a problem differently. Bringing in the form of peer review between project groups for initial iteration deliverables could assist in workload/burnout-related issues and benefit the students. However, when implementing such a process, one would have to weigh up the initial time required to administratively set it up versus the amount of time otherwise spent on marking.

Further, the required co-requisite modules for PBL modules could be investigated to reduce the number of students registered for a PBL module and increase the quality of students progressing to the PBL module. For large cohorts of PBL module students, group work should be employed to lighten the load on the lecturer. In such instances, it is also important to realise that the lecturer needs assistance from additional staff members to maintain the quality of teaching and learning.

5. Conclusions, Limitations and Future Research

The findings of this study contribute to the broader discussion on work overload and academic burnout in PBL modules compared to traditional ones. Moreover, these findings align with and support the existing literature, emphasising the factors and themes previously identified.

This paper provides insights into the increased workloads associated with software development PBL modules compared to traditional modules, highlighting the increased levels of academic burnout often experienced by lecturers delivering these intensive modules. The perceptions and reflections from this study underscore the urgent need

for higher education institutions and higher management to reassess and adjust the demands placed on academic staff, particularly those navigating the complex dynamics of PBL teaching.

Suggestions such as the integration of workload redistribution, integration of support systems, and the creation of new pedagogical approaches not only provide practical solutions but also allow for future research. Future research could look closely at the causes and factors contributing to academic burnout in lecturers teaching software development PBL modules, as well as the effectiveness of different management techniques and how they affect the outcome of students and the well-being of lecturers.

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ChatGPT Performance on Computer Science and Information Systems Course Examinations

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Abstract. Artificial Intelligence (AI) tools are increasingly being used in business and educational applications. The latest generative AI tools have disrupted and transformed the education sector globally. ChatGPT, one of the large language model platforms, has challenged and changed the educational landscape for educators and students. ChatGPT passed 12 out of 15 MBA modules in 2023 in South Africa. The research question addressed in this paper was can ChatGPT pass Computer Science (CS) programming modules and Information System (IS) modules presented at the university level in South Africa?

The 2023 November examination papers for selected Computer Science (CS) and Information Systems (IS) modules were presented to ChatGPT, the answers were generated and marked by the specific course examiners. ChatGPT passed 80% of the modules. The feedback provided by the examiners was that ChatGPT in the 1st year C# programming examination performed well and in the IS modules, successfully provided facts and information, however, when new case studies were used in the examinations, reference to the case study and application and insight were limited. Suggestions are provided on how academics can use ChatGPT in CS and IS modules and by providing case study context, improve ChatGPT responses, achieving higher marks. This is the first study of this nature using CS and IS course examinations conducted in South Africa.

Keywords: ChatGPT, CS and IS Examinations, AI in education.

1. Introduction

Artificial Intelligence (AI) is becoming increasingly prevalent in various sectors, including higher education [1]. AI and AI-based chatbots are transforming the approach to education [2]. Many studies have been published in which ChatGPT (Generative Pre-trained Transformer) obtained better or similar results compared to those obtained by students in different contexts and official exams [3, 4, 5]. Vasquez-Cano et al. [6] concluded that ChatGPT was the brightest student in the class in a reading comprehension test. Concerns regarding ChatGPT in education include the assessment of students [7]. ChatGPT has vast applications in education, research writing and scientific advancement [8]. ChatGPT is a large language model (LLM) and an AI-powered chatbot by OpenAI [9]. It is a revolutionary tool that responds to enquiries on nearly everything available in the contemporary digital environment.

ChatGPT is proficient in multiple programming languages and has the capacity to facilitate multilingual communication. UNESCO proposes three dimensions of linking

AI and education [10] namely, learning to use AI tools in the classroom; learning to know AI and its technical possibilities and raising public awareness of the impact of AI on people's lives. Academic integrity and adjusting exams and assessments to avoid the misuse of AI tools, specifically ChatGPT are pressing issues in education [11]. Malinka et al. [12] go so far as to say that ChatGPT has brought in an era of the change of teaching practice for many disciplines.

ChatGPT is performing well in natural language-related tasks, such as translation, question answering, summarising, writing essays and computer programming [6]. ChatGPT has implications for technical fields as well, specifically Computer Science as it can simplify creative activities, such as programming [12]. ChatGPT should be a tool for improving students' skills by fostering their ability to ask questions and formulate them precisely, expanding their knowledge through ChatGPT's answers and teaching skills to assess the accuracy, reliability and quality of ChatGPT's answers as well as to filter the pertinent information gleaned from answers [9].

AI in education is known as AIEd. AI has multiple areas for AI applications in education. It can be built into learning activities for ongoing analysis of student achievement [13]. Many academic support activities can benefit from AIEd. These include admissions by streamlining enrolment with tailored approaches to individual student needs, which include personalised assistance with finance, scheduling and guidance [14].

The art of crafting prompts for ChatGPT involves clear communication, providing context and defining the task clearly [15]. Articulation becomes a pivotal skill in the realm of AI because clarity breeds accuracy. The way the user frames the prompts, the specificity, clarity and context directly influence the quality of the response. The user must understand the processing capabilities of AI and leverage them through clear communication [15]. Articulation becomes very important and can influence the answers generated when submitting examination questions to ChatGPT, based on a case study.

In the USA, ChatGPT passed an MBA Operational Management module exam in 2022 at the Wharton Business School [4]. In South Africa, research conducted in 2023 has shown that ChatGPT passed 12 of the 15 MBA modules from different Business Schools in South Africa [3]. The research question addressed in this paper was can ChatGPT pass CS programming and IS modules presented at a South African university? In this paper, ChatGPT was used to answer questions in examination papers written in November 2023 for Computer Science programming modules and for selected Information Systems courses.

The research problem and objective are discussed in Section 2. The literature on the use of ChatGPT is discussed in Section 3. In Section 4, the research methodology is presented, and the findings of the study is presented in Section 5. The conclusions, recommendations of this study and future work are discussed in Section 6.

2. The Research Problem and Objective and Design

ChatGPT passed an MBA exam for an Operations Management Course from the Wharton Business School [4]. The 2023 examination papers for MBA modules from different Business Schools in South Africa were presented to ChatGPT, answers were generated and marked by the specific course examiners. ChatGPT passed 12 of the 15

modules [3]. The feedback provided by the examiners was that ChatGPT successfully provided facts, however, when new case studies were used, the application could not produce correct answers nor insight and application.

Presently in South Africa, teachers and lecturers are generally unaware of the capabilities of ChatGPT, specifically relating to CS and IS examination papers. The objective of this study was to ask lecturers in a Department of CS and IS to provide their November 2023 examination papers to the authors, who then submitted the examination questions of the papers to ChatGPT. The ChatGPT answers were captured in examination scripts and the lecturers were requested to mark the script together with the students' papers been marked.

3. Literature Review

The greater or lesser potential for learning ChatGPT lies in the methodological and didactic proposals used inside and outside the classroom [6]. It is the teacher or lecturer who must first establish the design of activities based on ChatGPT in a virtual tutor format [16]. The design of initial prompts improves aspects of style and content in the summaries to later contrast and highlight the changes made and the reasons for them from a critical perspective. This enables expanding the creativity of the answers and not copying them [6].

The LLM for ChatGPT is based on a deep learning architecture known as Generative Pre-trained Transformer (GPT), which is trained based on a vast amount of text data to produce human-like responses in natural language conversations [6]. It was developed in 2018 and introduced in 2022 and ChatGPT 4 has been released in 2024. Every version has vast improvements and increased functionalities. Wheeler [17] reports that AI has had little impact on teaching and learning in higher education because education tends to lag behind where new technologies are concerned. In addition, the lack of willingness to take risks, or to adopt new innovations and the lack of funding for anything different from traditional methods of teaching mitigate against the adoption of new technologies in all sectors of education, learning and development [17].

ChatGPT in higher education has raised many questions about the authenticity of assessments and challenges in detecting plagiarism [18]. ChatGPT has introduced new challenges and threats to education. The implications of ChatGPT-assisted learning require attention so that the benefits are optimised, and the drawbacks minimised [19]. Romero-Rodriguez et al. [2] highlight the following risks associated with the use of ChatGPT:

- The answers Chat GPT provides contain errors [19];
- The acquisition of key competencies are affected; and
- Responses could contain socio-cultural and training base biases [18].

The researchers [2; 18; 19] do however highlight benefits as well, which include the importance of ChatGPT in improving the teaching and learning processes, developing creativity and critical thinking skills, training and searching for literature. Another positive is the fact that students get instant feedback and answers [20]. Nikolic et al. [18] add that ChatGPT improves engagement and student experience, increases accessibility and inclusivity and can improve learning outcomes. Javaid et al. [9] propose the following significant applications of ChatGPT in education:

- Enhance critical thinking and communication abilities;
- Provide instructional material;
- Conversations with students;
- Enhance reading and writing abilities;
- Virtual teaching assistants;
- Teaching students to ask better questions;
- Solving complex problems;
- Topic brainstorming and creativity;
- Personalised learning;
- Text analysis;
- Enhance the learning environment;
- Research tool;
- Save teachers time; and
- Student evaluation.

The risks and limitations of using ChatGPT include the fact that it sometimes provides incorrect answers, the ethical issues of plagiarism, issues of bias and the greatest concern of students not producing their own work. Nikolic et al. [18] raise concerns about ChatGPT compromising academic integrity. The shift to online has heightened concerns because of increases in cheating behaviour. Sullivan, Kelly and McLaughlin [19] refer to ChatGPT as a tool to facilitate student cheating. They call for a need for students to be educated on how AI relates to academic integrity and to use AI as mentioned by Javaid et al. [9]. Plagiarism tools, such as Turnitin now also check for AI-generated text and provide an AI text generation score.

ChatGPT's ability to facilitate plagiarism not only impairs academic integrity but also defeats the purpose of assessment, which is to evaluate student learning fairly [21]. Gregoric and Pendrill [22] found that ChatGPT-3.5 is not yet good enough to be used as a cheating tool for physics students or as a physics tutor. However, they found it quite reliable in generating incorrect responses on which physics teachers could train the assessment of student responses. Dempere et al. [14] encourage faculty members to use AI tools, such as ChatGPT proactively and ethically to mitigate risks, especially academic fraud. They propose that digital literacy training must cover the risk of plagiarism when using AI chatbots appropriately.

4. Research Methodology

Academics lecturing Computer Science programming and Information Systems modules at the Nelson Mandela University in Port Elizabeth, South Africa were requested to provide their 2023 examination papers to be 'answered' by ChatGPT [23]. Five lecturers agreed to participate in the study, a first-year C# programming module, a 2nd year Hospitality Management IS module, a 3rd year Enterprise Systems Development module and two honours modules, namely Project Management and Business Intelligence.

The authors copied each question into an examination paper and submitted it to ChatGPT. The time taken to provide the answer was also recorded. The answers were

then ‘snipped’ and placed in the examination script. On completion, the examination script was emailed to the lecturer with the request to mark the script. The lecturer then provided a final mark and also provided some thoughts on the answers and experience marking a ChatGPT generated answers. This study was qualitative as insights were sought from the lecturers.

Two versions of the ChatGPT examination answers were generated from examination papers making use of a case study. One examination answer script where the case study was not presented and analysed by ChatCPT, i.e. the case study was included with the first question on the examination paper. A second version of the examination answer script was additionally generated, where ChatGPT was provided with the case study and first presented to analyse the case study, before presenting the examination questions. In the second case, ChatGPT was ‘trained’ on the case study before answering the examination questions.

5. Results

The students’ lowest, highest and class average marks for the five courses are provided in Table 1. The examination papers ChatGPT provided answers for are also listed in Table 1. The average time for ChatGPT to complete the examination scripts was 6 minutes, with an average mark for the five papers being 62%. Papers making use of a case study, ChatGPT provided two answer scripts, one without the case study analysis beforehand and the second, first asking ChatGPT to analyse the case study, then instructing it to refer to the case study when answering the examination questions. The second exercise saw an increase for three subjects in marks by 7% (71% vs 78%).

Table 1: CS subjects, student exam marks, ChatGPT time to complete and marks

Course	Paper type	Duration/ marks	Students			ChatGPT		
			Low mark	High mark	Ave	Time to complete	Marks	Case study analysis
1 st year C# programming	Exam	3 hours	32%	98%	71%	7 min 50 sec	68%	---
2 nd year Hospitality Management Information Systems	Case study	2 hours 100 marks	55%	86%	70%	5 min 10 sec Quiz 20/20	78%	84%
Enterprise Systems Development 3	Case study	2 hours 100 marks	40%	76%	52%	3 min 40sec	30%	---
Project Management 4	Case study	2 hours 100 marks	40%	87%	61%	9 min 30 sec	68%	76%
Business Intelligence 4	Case study	2 hours 100 marks	45%	81%	59%	7 min 10 sec	66%	73%
Average						6 min 5 sec	62%	78%

1st year C# programming examination

The final 1st year C# programming examination consisted of 2 questions, one a smaller Graphical User Interface (GUI) question, the other a much bigger one with object class, list class, application class and making use of indexing. The final mark for the programming examination by ChatGPT was 68%.

ChatGPT's mark was 9/10 for Question 1. The only mark lost was for currency formatting – the ChatGPT answer had the “R” symbol as part of the final text, instead of making use of currency formatting. The difference is that if the PC was set to use a different currency, the “R” symbol would now be incorrect. This aspect was stressed in the module during lectures. The question 2 mark was 45/70. The marks were allocated as follows:

- Inventory item class provided – no marks allocated (Figure 1)
- InventoryManager class: 18/29
- Index class provided – no marks allocated
- IndexList class: 18/23
- Application class: 9/18

```
0 references
static void Main(string[] args)
{
    InventoryManager inventory = new InventoryManager();
    IndexList nrIndexList = new IndexList();

    inventory.BuildIndex(nrIndexList);

    DisplayOptions();
    int choice = int.Parse(ReadLine());
    ProcessOption(inventory, nrIndexList, choice);
    while (choice != 6)
    {
        DisplayOptions();
        choice = int.Parse(ReadLine());
        ProcessOption(inventory, nrIndexList, choice);
    }
    ReadLine();
}

2 references
static void DisplayOptions()
{
    WriteLine("Choose one of the following options: ");
    WriteLine("1. Add a new inventory item");
    WriteLine("2. Delete an inventory item");
    WriteLine("3. Update inventory item quantity");
    WriteLine("4. Calculate inventory value");
    WriteLine("5. Display all inventory items");
    WriteLine("6. Quit");
    Write("Choice: ");
}
}
```

Fig. 1: Inventory item class provided

In the module, students were taught to keep aspects separate as follows:

- Object class – constructor and methods linked to a single object of this type (for this question there were two object classes: one for inventory item object and the other for the index object);

- List class – constructor and methods specifically linked to the list of objects (for this question there should have been two list classes: one for the InventoryManager and the other for the IndexList); and
- Application class – all user interactions, menu presented to the user, as well as prompts and feedback to the user.

2nd year Hospitality Management Information Systems Exam

The new self-generated case study was used in the examination, which described a new hotel, The Riverside Boutique Hotel, its amenities, services and operation. The performance of ChatGPT in an examination improved when the case study was presented to ChatGPT and asked to analyse the case study. The author ‘trained’ ChatGPT on the case study for a second time before presenting the questions. The analysis of the case study by ChatGPT is provided in Figure 3.



Fig. 2: Multiple choice question

The multiple choice (MC) questions were presented to ChatGPT (Figure 2) and the scores obtained were 20 out of 20. The 20 MC questions were answered in 45 seconds.

Question 2 of the examination script asked students to identify the types of information systems required by a hotel. These types of questions ChatGPT answers very well and provide extensive detail (Figure 3). Question 3 focused on the role of ferries in the hospitality industry and ChatGPT scored 10/14 for the question “Discuss the impact of Ferries in the hospitality industry”. Question 4 focused on hotel procurement management and Human Resource management and ChatGPT scored 23/25 for the questions. Overall, ChatGPT on the first attempt, not analysing the case study first, scored 78% and the second attempt, after the case study analysis (Figure 4)

and then presenting the questions with reference to the case study, the mark for the examination improved to 84%.

Question 2	(20)
<p>a) The management of the boutique hotel needs an Information System for the hotel. Discuss the types of information systems needed for a hotel. (6)</p>	
<p>In the hospitality industry, hotels require various types of information systems to efficiently manage their operations and deliver an excellent guest experience. These information systems serve different functions and can be integrated to streamline hotel management. Here are some of the key types of information systems needed for a hotel:</p>	
<p>1. Property Management System (PMS):</p> <ul style="list-style-type: none"> • A PMS is the central hub of hotel operations. It manages reservations, check-ins, check-outs, room assignments, billing, and more. It tracks guest information, preferences, and history. • The PMS helps in managing room inventory, optimizing occupancy rates, and ensuring smooth front desk operations. 	
<p>2. Point of Sale (POS) System:</p> <ul style="list-style-type: none"> • POS systems are used in hotel restaurants, bars, and other outlets. They handle orders, payments, and inventory management for food and beverages. • POS systems can be integrated with the PMS for seamless billing and guest charges. 	
<p>3. Customer Relationship Management (CRM) System:</p> <ul style="list-style-type: none"> • CRM systems help hotels manage guest interactions, preferences, and feedback. This information is valuable for personalized service and marketing. • A CRM system can help the hotel build and maintain strong relationships with its guests. 	
<p>4. Online Reservation System:</p> <ul style="list-style-type: none"> • An online reservation system allows guests to book rooms and services through the hotel's website. It should be user-friendly and integrated with the PMS to ensure accurate availability and pricing information. 	
<p>5. Channel Management System:</p> <ul style="list-style-type: none"> • For hotels that sell rooms through various online travel agencies (OTAs), a channel management system helps in managing room inventory and rates across multiple platforms. 	
<p>6. Revenue Management System:</p> <ul style="list-style-type: none"> • This system helps optimize room rates based on demand, market conditions, and other factors. It maximizes revenue by adjusting pricing dynamically. 	
<p>7. Accounting and Financial Management System:</p> <ul style="list-style-type: none"> • This system manages the hotel's financial transactions, including accounts payable, accounts receivable, payroll, and financial reporting. It ensures financial accuracy and compliance. 	
<p>8. Housekeeping Management System:</p> <ul style="list-style-type: none"> • Housekeeping systems track the status of rooms, schedule cleaning, and manage the allocation of resources for cleaning staff. This ensures efficient room turnover. 	
<p>9. Security and Access Control System:</p> <ul style="list-style-type: none"> • These systems are crucial for guest safety and the protection of hotel assets. They control access to secure areas and monitor security camera feeds. 	
<p>10. Inventory Management System:</p> <ul style="list-style-type: none"> • For hotels with extensive on-site stores or gift shops, inventory management systems help control stock levels, order supplies, and manage vendor relationships. 	
<p>11. Guest Feedback and Survey System:</p> <ul style="list-style-type: none"> • This system collects feedback from guests, allowing the hotel to gauge satisfaction and make necessary improvements. It can be integrated with the CRM system for guest profiling. 	
<p>12. Human Resources Management System (HRMS):</p> <ul style="list-style-type: none"> • HRMS handles employee data, payroll, attendance, training, and recruitment. It ensures efficient workforce management. 	
<p>13. Energy Management System (EMS):</p> <ul style="list-style-type: none"> • An EMS helps hotels optimize energy usage, reduce utility costs, and meet sustainability goals. It can control lighting, HVAC, and other systems. 	
<p>14. Business Intelligence (BI) and Analytics System:</p> <ul style="list-style-type: none"> • BI systems collect and analyze data from various hotel systems to provide insights into performance, trends, and opportunities for improvement. 	
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Fig. 3: Question 2 ChatGPT answers

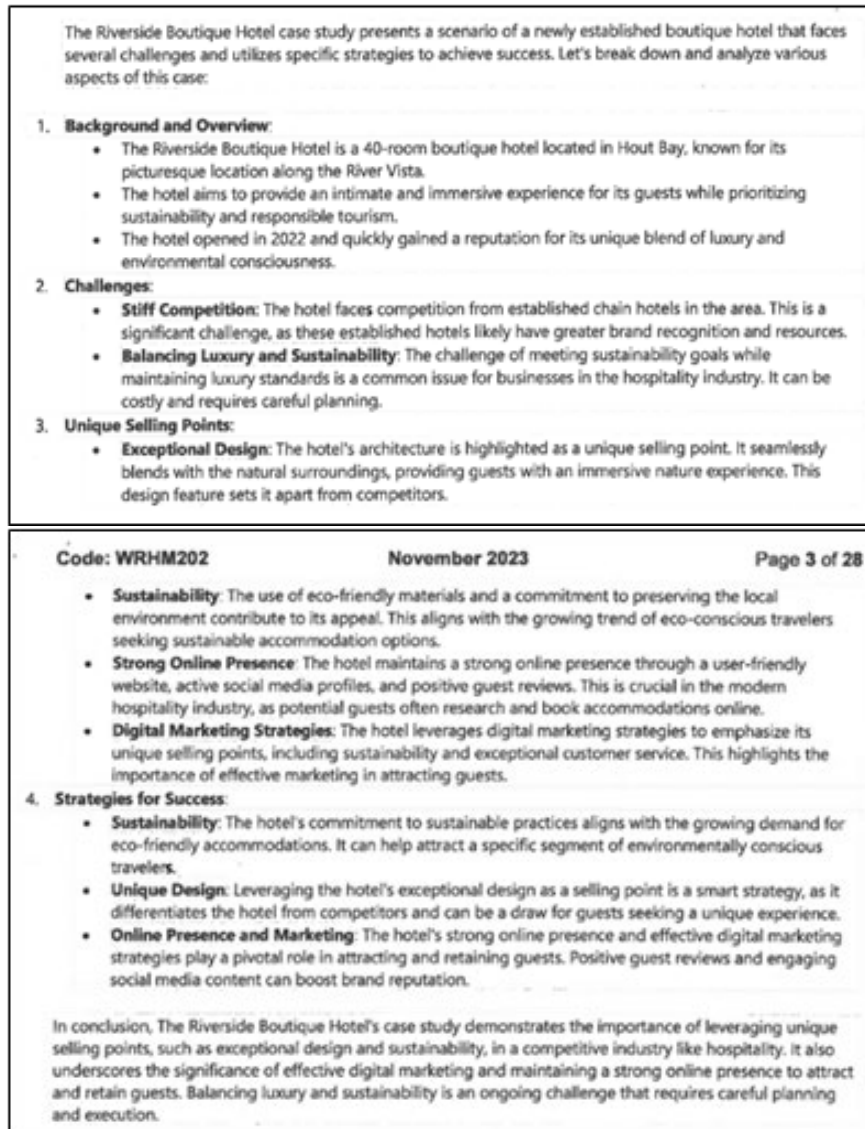


Fig. 4: Analysis of case study

Enterprise Systems Development 3

ChatGPT only scored 38% for this paper. The first questions of the examination paper, focused on ERP system implementation and the implementation process. Here ChatGPT scored 12/12 and for the second question on ERP customisation, 6/10. ChatGPT scored 8/8 for the question comparing the CRISP-DM model for data mining with the SAS methodology for data visualisation.

The remainder of the examination paper focused on User Interface design (UX) and the images could not be analysed by the older version 3 of ChatGPT. The latest version 4, released in February 2024 can analyse pictures and the results for this paper could be significantly higher. The final question for 20 marks required the students to design reports using SAS Visual Analytics.

Project Management (PM) and Business Intelligence (BI) honours modules

The structure of these examination papers was similar, where students were required to read a case study and then answer PM and BI questions relating to the case study. ChatGPT obtained a mark of 68% for PM and 66% for BI. Again, having ChatGPT analyse the case studies first, the PM marks improved to 76% and BI to 73%.

The performance of ChatCPT in Computer Science

In a study by Qureshi [24], two groups of Computer Science students were given programming challenges, as part of a Data Structures and Algorithms course, to solve within a short period of time. The control group (Group A) had access to textbooks and notes of programming courses, however, no Internet access was provided. Group B students were given access to ChatGPT and were encouraged to use it to help solve the programming challenges. The findings showed that students using ChatGPT obtained higher scores, however, there were inconsistencies and inaccuracies in the submitted code consequently affecting the overall performance and scores.

ChatGPT's performance varies across different subjects in an undergraduate CS program. ChatGPT is best suited to answer prompts that are coding sourced from leetcode and have a context-setting prompt, as it achieved a mark of 93% [25]. The authors [25] recommend that undergraduate students must use the resources provided by the instructors, such as well as reliable online resources to grasp the subject matter. Once they have understood the subject matter, they can further use ChatGPT to generate practice questions for tests and exams [25].

Krüger and Gref [26] indicated that ChatGPT-3.5 achieved an average of 80% in the ten Computer Science modules tested. ChatGPT performed particularly well in modules with a high proportion of web development or high-level programming language content, such as Python and JavaScript. ChatGPT-3.5 achieved almost full marks in the Data Science module and exams with more complex tasks, such as Operating Systems or Data Network Management, ChatGPT provided an approach to a solution.

Academics have been debating the ethical use of ChatGPT in education. The ethical risks include compromised data privacy, biased inputs, inaccuracies/misleading results, unreliability and plagiarism. Joshi et al. [25] recommend that in open-book tests and examinations, including take-home assignments students could plagiarise responses from ChatGPT, which in turn lowers their academic integrity and hinders their learning.

Lessons learned from the ChatGPT examination exercise

The following are observations made by the authors:

- ChatGPT has inconsistencies and can answer basic questions incorrectly;
- ChatGPT can generate code in C# and Python for example, however, a student must be able to understand and evaluate the code to determine if it is correct;
- Do not use case studies available on the Internet;
- Prompting ChatGPT without laying down the context tends to lower the response accuracy;
- ChatGPT can assist with generating new case studies;
- ChatGPT must be ‘trained’ by analysing a new case study before submitting examination questions;
- ChatGPT is very good at answering multiple-choice questions;
- Images could not be analysed, however, GPT-4 has this capability;
- Questions that can be “Googled”, i.e. the information is available on the Internet, ChatGPT answers well;
- There is a higher accuracy reported for theoretical questions, as were asked in the PM and BI examinations; and
- CS and IS students must be provided with guidelines to help them use ChatGPT ethically.

6. Conclusions, Limitations and Future Research

The effective integration of AI tools, such as ChatGPT in education is critical. It must start from a methodological debate determining how to use these tools in a productive, responsible, critical and analytical way in support of learning and professional development [6]. Further research is required on the perceptions and training of university faculty [2]. Higher education must respond adequately and immediately to the increasing quality of tools, such as ChatGPT, Claude and Gemini.

Students need to learn to use ChatGPT ethically because it is too hard to ban and because they need to use it in the workplace [19]. Sam Altman, the CEO Open AI, said “There may be ways we can help teachers be a little more likely to detect output of a GPT-like system. But honestly, a determined person will get around them”. He added that teachers and lecturers must adapt and test students differently [7]. Higher Education Institutions should use knowledge of AI’s impact on the job market to adjust their curriculum by prioritising skills AI cannot replicate, such as problem-solving and critical decision-making. They can also teach students to use and develop AI to their advantage, which will prepare them for the changing job market and ensure their success in the workplace [14].

The latest generative AI tools have disrupted and transformed the education sector globally and in South Africa. ChatGPT, one of the LLMs platforms, has challenged and changed the educational landscape for educators and students. ChatGPT passed ten Computer Science modules tested and obtained an average mark of 80% [26]. The objective of this study was to measure the performance of ChatGPT on a selected CS programming module and selected IS modules. ChatGPT passed four out of the five CS

and IS modules, including the first-year C# programming module with 68%. The study also focussed on training ChatGPT on new case studies before answering examination questions.

A number of important lessons were learnt in this exercise. Training or familiarising ChatGPT with a new case study allows it to answer the questions and refer to the case study. At the time of this study, the authors used ChatGPT-3.5 [23]. The results obtained in the 3rd year examination paper would significantly change using GPT-4, which can accept images as part of a prompt and provide an accurate text response and generate images.

Generative AI systems, such as ChatGPT can give inaccurate results, which raises the question: can ChatGPT be trusted? Other concerns include the issue of bias and ethical risks. Educators and students need to be trained on the drawbacks of ChatGPT, which include humanlike responses compared to a tool like Google, which offers relevant results [22]. Incorporating AI in higher education brings about various opportunities and challenges. Universities can efficiently manage these apprehensions by adopting a proactive and ethical stance toward the implementation of such tools [24].

The art of crafting prompts and interaction with AI tools involves clear communication, providing background and context to the questions and defining the task clearly [15]. This is specifically important when using case studies in examinations and wanting ChatGPT to answer questions relating to the case study. This study has shown that by allowing ChatGPT to analyse the case study, providing clear prompts before submitting examination questions, increased the accuracy of the responses and increased the marks ChatGPT obtained for the examination scripts.

The limitations of this study are that only five modules were used, specifically only one first-year Computer Science programming module. Future research will focus on including more CS programming modules at different year levels and other IS modules in the study, including examination papers from different universities. In addition, Gemini has been released and a comparison between the answers provided by ChatGPT-4 and Gemini will be investigated.

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Reflective Analysis of the Impact of an Induction Programme for Honours in Computer Science and Information Technology Students

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Abstract. The purpose of the paper is to present a reflective analysis of the value of an induction programme for Honours in Computer Science and Information Technology (CSIT) students. The experiences of students over a two-week period are evaluated. The methodology followed was reflecting on the experiences of students after they completed a pre- and post-questionnaire. Both quantitative and qualitative data were collected. The induction programme has as aim to bridge the gap between undergraduate and post-graduate studies. Furthermore, it prepares the students for the academic year ahead. Findings indicate that the students perceived the programme to be of value and different levels, -social, academic, and enhancing certain graduate competencies and soft skills. It further has consequently, revealed certain potential changes that can be made by the faculty presenting the induction programme for future endeavours. The paper's main contribution is to add to the literature on induction programmes specifically for honours CSIT students.

Keywords: Induction programme, Graduate attributes, Computer Science and Information Technology students, Honours programme, Soft skills, Lego Robotics, Challenges, Reflection.

1. Introduction

The transition from undergraduate to postgraduate studies is an important aspect in the academic careers of Computer Science and Information Technology (CSIT) graduates. Induction programmes are essential in helping students as they navigate the upcoming academic obstacles. These programmes are designed to provide students with the skills and knowledge necessary to succeed in their academic endeavours by addressing both academic and social challenges.

The COVID-19 pandemic further highlighted the significance of induction programmes even more, since students had particular difficulties adjusting from a remote- and online learning environment back to face-to-face learning environments.

The aim of this paper is to reflect on the effectiveness of an honours induction programme, in fostering academic readiness, social interaction, and the development of essential graduate attributes, by using the feedback (pre- and post-test) of CSIT students on their experiences of the induction programme and do a comparison of collected data.

The paper is structured as follows: Section 2 presents background and relevant literature of the study, Section 3 discusses the format of the induction programme while Section 4 presents the research methodology. The interpretation and discussion of the qualitative and quantitative data are provided in Section 5. The paper concludes in Section 6 with a summary and future work.

2. Literature Review

2.1. Induction Programmes

Induction programmes play a crucial role in equipping students with the necessary skills and knowledge to not only adjust and transition into the new environment, but to excel in their academic endeavours [1]. The purpose of these induction programmes is to prepare students for the academic challenges, problem-solving, and research expectations ahead as well as to provide an opportunity for social interaction with their peers and supervisors. According to Farrell *et al.* [2], the two key elements of an induction and orientation programme are academic readiness and social readiness.

From a faculty-led undergraduate teaching and learning approach to a student-centred postgraduate approach; there is a shift in responsibility whereby students are expected to take greater ownership of their studies. This induction programme attempts to assist CSIT students in navigating this academic transition towards a more self-directed approach. In addition to academic preparedness, this induction programme also facilitates the often left-behind social initiative that is essential to student development and success. Social engagement activities such as group projects provide an excellent opportunity for students to actively engage with their fellow students.

In a paper by Stalhane *et al.* [3], the employability of CSIT students is of great importance. The respondents were questioned about the qualities they felt university candidates should possess. The most frequently reported weaknesses were lack of adaptability, actual coding and maintenance experience, problem-solving skills and poor customer communications abilities.

The CSIT students that participated in this research commenced their studies during the COVID-19 pandemic. These students were faced with unique challenges as they were forced to a sudden shift to remote- and online learning environments. Not only were their academic routines disrupted, but their social interactions were also limited, hindering their opportunities for social growth and development. Now that these students transition back to face-to-face learning, induction programmes are especially important for students to adapt and adjust to the academic and social dynamics of face-to-face learning.

2.2. Graduate Attributes

Each educational institution wants to prepare their graduates to have essential skills to be ready for their career and the emergent nature of the world of work that lies ahead. The North-West University (NWU) aims to equip its graduates with the necessary competencies to thrive in the contemporary landscape of the twenty-first century. To achieve this, the University outlines desired attributes across various domains [4] including:

- Responsible and engaged members of society: This includes value attributes such as a willingness to take responsibility for the consequences of their actions and decisions, an awareness and understanding of moral and ethical issues including environmental mindfulness.
- Work readiness, encompassing qualities such as knowledgeable, highly educated graduates with an entrepreneurial aptitude.
- Vital transferable skills, which entail effective communication, innovation, critical thinking, and ethical leadership.

Moreover, CSIT professionals should possess and develop not only technical skills but also soft and interpersonal skills, to be able to function optimally and thrive in the fast-changing CSIT industry. Stress tolerance, adapting to new team members, managerial skills, and being able to influence others (and vice versa) are also needed skills [5, 6, 7].

Hence, an induction programme should aim to cultivate these essential skills among graduates, aligning with the overarching goal of preparing them for the demands of their future careers.

3. Format and Activities of the Induction Programme

3.1. Rationale for this Induction Programme

Benefits of an induction programme can be on social, personal, and academic/technology levels [8]. In a very short amount of time, the students learn to become proficient with new technology and apply it to solve problems. These students also spent time during the COVID-19 pandemic working alone and virtually. They must now be able to work in groups; also with people who are mostly strangers to them. After determining the strengths and weaknesses (or growth points) of their classmates, they must divide and assign work appropriately. Additionally, students have the chance to socialise and interact with staff members as well as with their peers. By the time the academic year begins, this helps the staff and students to be acquainted with one another. Furthermore, the students will have more knowledge about the year's activities that lay ahead and certain graduate attributes will have been addressed during the induction programme, by taking part in group events and begin challenged to be creative and solve problems.

3.2. Induction Programme Activities

The two weeks leading up to the start of formal classes are dedicated to the induction programme; as a preparatory initiative. The school management team greets the new students when they arrive on the first Monday of the programme. Administrative matters are addressed during the welcoming session. They can also claim their own workspaces in the labs and receive training on lab etiquette and computer labs. Following the orientation, the students are divided into four-person teams.

The facilitators (a group of academic staff members) select team leaders, who in turn select their team members to form the teams. The facilitators rotate the team members for every session, while the team leaders remain constant throughout the programme.

Every student in the cohort should work in a team with every other student. For the length of the programme, a Lego EV3 set is given to each team leader.

3.3. Sessions

There are morning and afternoon sessions on most days. A session starts with the announcement of the new teams and the challenge for that particular session. After spending three to four hours building and programming a robot to perform the task, the students present their work to the class at the end of the session. The team leaders are given the scores once the solutions have been scored. The team leaders are also required to designate which member of their team contributed the most value during each session.

Examples of the challenges the students have to solve:

- Constructing and programming a line-following robot is the first challenge. A mat is utilised that has a line printed on it that is roughly one centimetre broad and has splits and junctions. During the first challenge, the Lego Mindstorms Education EV3 Classroom App is utilised. Since most students have never used Lego Mindstorms or even Lego, the first session's goal is to acquaint students with the process of creating robots out of Lego, programming them, and using sensors. The robots' time to follow the line from beginning to conclusion is used to determine how well they performed in this task. There are additional penalties for each time a team member handles the robot, such as returning it to the initial line. These rules are made clear to the teams.
- Secondly, students are exposed to a real-world application of finite state machines, which is a fundamental aspect of compiler theory, software engineering, and natural language processing. Since the second challenge is a repetition of the line-following task, students can apply a lot of the strategies they used in the first challenge. But now they must use Python to programme their robots. Moreover, the line that follows has an extra layer of complexity: The robot must react differently when it reaches distinct colours or colour combinations that are adhered to the line by coloured insulation tape strips. For instance, the robot must stay to the left of the next line split when it comes across a blue strip. Alternatively, the robot must do a U-turn, retreat 30 cm, and then proceed to ignore the first red strip it comes across.
- Maze solving is involved in two additional difficulties. For the first part, students must utilise ultrasonic distance sensors to navigate a real maze made of wooden boards. The second part of maze solving, as an additional layer of complexity, the robots must react differently when it reaches distinct colours encountered on the maze floor; as was done with the line following colour strip combination.
- There are also challenges that are not Lego-based. Constructing an email server is one of these challenges. The students have 72 hours over the course of the weekend to finish this assignment after which they have to demonstrate the features and functioning of their email server.

3.4. Academic Related Activities

The structure and modules presented in the honours degree are explained during a session. Staff members have the chance to visit the students and tell them about the modules they lecture, providing the information the students need to know in order to choose which modules to register for. Additional information provided is the details of the projects that are available for their required project module.

3.5. Conclusion of the Programme

A barbeque is scheduled for one afternoon, near the end of the programme. This event is attended by all academic and support staff members as well as the students. This allows the students and staff to socialize. They also take this chance to learn more about the modules available as well as the projects that interest them.

Battle of the Bots is an entertaining (and competitive) event that takes place towards the end of the programme. Team leaders have the authority to select their own members for this particular competition. All of the robots are positioned inside a marked area that measures approximately 2 by 3 metres. Bluetooth connectivity allows for remote control of robots from mobile phones. Robots are to be pushed out of the arena, with the last robot standing being considered the winner. The students are very enthusiastic about this event and really enjoys this.

4. Research Methodology

This reflective study employs a cross-sectional survey-based method to gather feedback from CSIT honours students during the start of a yearly induction programme, as well as after their first month of classes. By collecting data after the start of lectures, the students had the opportunity to give feedback on the induction programme with the advantage of hindsight. The data was collected using two questionnaires which features both Likert-scale and open-ended questions and are designed to assess the perceived effectiveness of the induction programme. Content analysis is used as a primary method to analyse the responses, thereby providing insight into the perceived impact of the induction programme on their academic readiness and graduate attributes.

Both questionnaires are provided as anonymous, self-reported online questionnaires facilitated through Google Forms, and were distributed to the entire honours group by means of a URL. The questionnaires start with a question obtaining informed consent, followed by several questions collecting non-identifying biographical information such as age and gender. As the NWU University is a multi-lingual institution, information on home language(s) is also collected, as it may provide insight into some of the students' responses. The remainder of the questions are a mixture of quantitative (Likert-scale) and qualitative (open-ended) questions, for a total of 33 questions for the first questionnaire and 47 questions for the second questionnaire.

The qualitative data, collected using the open-ended questions, are evaluated using content analysis [9, 10]. The purpose of this evaluation is to determine the broader impact that the induction programme has on students' perceived skills, as well as to identify problems or weaknesses in the programme that can be improved upon. The NWU's Teaching and Learning Strategy document is used to identify the specific skills to focus on, as "*The NWU values and strives to develop the following skills that are*

viewed as essential to functioning effectively in life and the world of work in the 21st century, and are also integrated into the NWU graduate attributes” [4]. These skills include key literacies (e.g. information, financial & language literacy), transferable skills (e.g. creativity, negotiation, communication) and character traits (e.g. leadership, adaptability, integrity).

Only those students who are enrolled for the honours programme in 2024 are considered for inclusion in this study. This group includes students who were already in their second year when the COVID-19 lockdowns were lifted in 2022, and therefore still experienced the impact of the lockdowns from their first year at university. The first questionnaire contains five questions to ascertain whether or not this still has an impact on their academic experiences two years after the lockdowns were lifted.

In total, 27 (n=27) of the 34 students contacted completed the first questionnaire for a response rate of 79.4%, whereas 19 (n=19) useable responses were received for the second questionnaire for a response rate of 55.8%. While the responses do contain very valuable feedback that can be used to improve the induction programme, they are not necessarily generalisable due to the limited number of respondents.

In the next section, a quantitative overview is provided, followed by a qualitative analysis of the findings obtained from the two questionnaires.

5. Research Findings and Discussion

In this section, the study’s results are presented from a quantitative- and qualitative perspective. The quantitative results obtained from respondents using Likert-scale questions are presented first, followed by the qualitative results.

5.1. Quantitative Findings

A key goal of the study is to determine the effectiveness of the induction programme in preparing students for their honours year. To this end, the honours students of 2024 were asked to provide their insight on several issues by means of Likert-scale questions. A 4-point format is used for most questions to reduce the occurrence of neutral responses, and the responses “Not at all”, “Slightly”, “Moderately”, and “Very much” were the options given for most questions. For the few questions that did not follow this format, the options were adjusted so that they fit better within the question's context.

Firstly, the respondents are asked to provide their opinion on the gap that exists between their undergraduate and honours years. This question is included in the questionnaire that was distributed a month after the start of lectures and therefore is influenced by what the students experienced during their first month as honours students. The responses to this question are shown in Figure 1. They were also asked, as part of the second questionnaire, how useful they consider the induction programme to be; the responses for this question are shown in Figure 2.

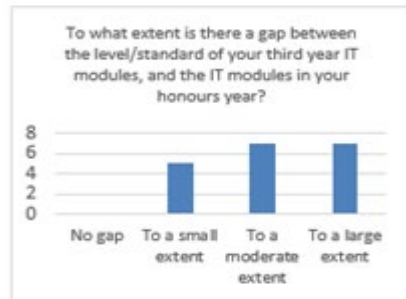


Fig. 1. Perceived gap between undergraduate and honours years (n = 19)

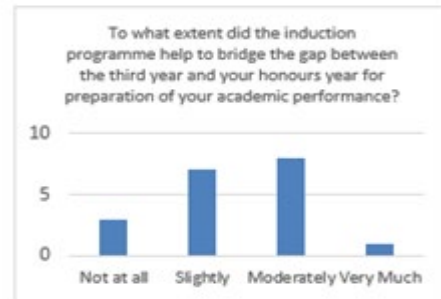


Fig. 2. Perceived value of the induction programme in addressing the gap (n = 19)

The responses, as shown, indicate that all of the respondents perceived a gap between the level/standard of their undergraduate and honours years, with 76.6% indicating a moderate to large gap. It is assumed that the students are capable of providing a reasonable, albeit subjective, evaluation of the academic gap between the third- and honours years. However, only 47.3% of the respondents felt that the induction programme helped to bridge this gap, with 36.8% indicating a slight advantage and 15.7% indicating that the induction programme did not help to close the gap at all. As there can be numerous reasons for this, a qualitative question is included in the same questionnaire to determine the cause of the gap. The results show that the gap is primarily caused by the inherent differences between how the undergraduate and honours programmes are presented. This is also touched upon in the next section dealing with the qualitative results.

The next set of questions deal with the perceived impact of the induction programme in advancing and developing the graduate attributes of students. In this instance, the respondents are asked to provide their perceived level as it relates to these attributes both before and after the induction programme, and therefore this set of questions is included in both questionnaires. The responses from the first questionnaire are shown in Table 1, indicating the perceived graduate attributes prior to the induction programme.

Table 1. Perception of graduate attributes prior to the induction programme (n = 27).

In your opinion: What is your current level of the following graduate attributes?	Not at all	Slightly	Moderately	Very Much	% Moderately / Very Much
Analysing and Investigating	1	2	17	7	89%
Communication	0	4	13	10	85%
Conflict resolution	2	4	13	8	78%

Creativity	1	7	15	4	70%
Employability	1	3	14	9	85%
Initiative/Self-motivation	0	4	15	8	85%
Integrity	1	0	8	18	96%
Planning and organising	0	6	14	7	78%
Self-awareness	0	4	14	9	85%
Stress tolerance	0	7	12	8	74%
Teamwork	0	3	17	7	89%
Time management	0	8	14	5	70%

The responses from the second questionnaire, following the induction programme and a month of lectures, are shown in Table 2. The change in perception between the questionnaires is also indicated in the final column of Table 2.

Table 2. Perception of graduate attributes following the induction programme and a month of lectures (n=19); change in perception indicated.

Now that you have gone through the induction programme - In your opinion: what is your level of the following graduate attributes? I am currently on an advanced level regarding:	Not at all	Slightly	Moderately	Very Much	% Moderately / Very Much	Change
Analysing and Investigating	1	0	10	8	95%	6%
Communication	1	1	14	3	89%	4%
Conflict resolution	2	3	7	7	74%	-4%
Creativity	1	1	15	2	89%	19%
Employability	2	2	11	4	79%	-6%
Initiative/Self-motivation	1	3	7	8	79%	-6%
Integrity	1	1	11	6	89%	-7%
Planning and organising	1	4	10	4	74%	-4%
Self-awareness	1	2	10	6	84%	-1%
Stress tolerance	2	6	5	6	58%	-16%
Teamwork	1	1	11	6	89%	1%
Time management	1	4	10	4	74%	3%

The collected data indicate that the participants consider their graduate attribute skills to be of an overall high level, with all of the responses being “moderately” to “very much” at least 70% of the time for all of the attributes with the first questionnaire. The attributes; “Integrity”, “Analysing and Investigating”, and “Teamwork” have the highest prevalence, with “Time management”, “Creativity”, and “Stress tolerance” being perceived as the least developed skills. When the changes that occurred after the conclusion of the induction programme are considered, “Stress tolerance” has the greatest reduction. It should be noted that “Stress tolerance” was already perceived as the third least developed skill prior to the induction programme, and that the skill with the lowest perceived level, “Time management”, improved slightly. “Creativity”, which is shown as one of the worst developed skills in the first questionnaire, showed the most improvement and is perceived as the third best skill following the induction programme. This improvement can be attributed to the students being exposed to techniques and methods that they were not familiar with beforehand, such as the development of problem-solving software for Lego robots.

When all of the skills that improved are considered, the data suggests that the induction programme in its current form is effective at helping students to further develop and polish critical problem-solving skills that are crucial to a successful honours year. The skills that showed the most reduction, such as “Conflict resolution”, “Planning and organising”, and “Stress tolerance”, are mainly skills that need various techniques, mindsets, and practice to master, and one possible explanation for the perceived reduction in these skills is that the students were not aware, prior to the induction programme, that their skills were actually of a lower level than expected. Even so, the students still perceived their skills to be of a high level, with only “Stress tolerance” having responses of “moderately” and “very much” in less than 74% of cases.

The next set of questions that are considered are included in the second questionnaire and focus specifically on students’ perceptions of the usefulness of the induction programme when specific aspects are considered. The responses to these questions are shown in Table 3.

Table 3. Student perceptions of the usefulness of the induction programme on addressing specific aspects.

How useful was the induction programme to you in terms of the following aspects:	Not at all	Slightly	Moderately	Very Much	% Moderately / Very Much
Getting to know my peers	0	0	4	15	100%
Getting to know the environment for doing honours	0	1	8	10	95%
Getting to know the lecturers	0	3	12	4	84%
Learning new soft skills	1	5	9	4	68%
Learning new technological skills	0	6	12	1	68%

Bridge the gap between undergraduate and postgraduate studies	2	6	7	4	58%
To prepare you for honours studies	2	6	8	3	58%
To make module and project supervisor selections	1	7	9	2	58%
Advancing my graduate attributes	1	8	7	3	53%
Alleviate anxiety/stress for the year ahead	4	9	5	1	32%

Of note is that the three aspects where the students found the programme the most useful; “Getting to know my peers”, “Getting to know the environment for doing honours”, “Getting to know the lecturers”, are primarily related to the social- and on-campus environment, whereas the three aspects where the programme is considered the least useful; “To make module and project supervisor selections”, “Advancing my graduate attributes”, “Alleviate anxiety/stress for the year ahead”, all relate to broader matters that are more relevant to the contents of the honours course itself. This suggests that the induction programme is fairly well-focused on making students more comfortable with the overall academic environment, which could have a positive impact on their academic performance. In this manner the induction programme fulfils its purpose, as the remainder of the honours course is intended to help develop these aspects to a much larger degree.

Finally, the students are asked to consider the impact that COVID had on their academic performance, and the perceived value of the induction programme in alleviating that impact. In the first questionnaire, only 41% of the respondents indicated that COVID made academic performance moderately to very challenging, with 41% indicating that it made a slight impact. 42% of the respondents, after the conclusion of the induction programme, proceeded to indicate that the programme helped “moderately” or “very much” in alleviating the impact of COVID isolation. They were also asked to elaborate on their answers using an open-ended question; the responses to these questions will be discussed in greater detail in the next section.

5.2. Qualitative Findings

Both of the questionnaires contained open-ended questions so that deeper insight into the induction programme could be obtained from the respondents. Some of the more prominent themes observed from the responses are discussed in this section. The questions are repeated here, followed by the observations that are based on the feedback received. In the event that a response is quoted verbatim, the respondent is identified with P#.

Which two aspects of the induction programme stood out as most satisfying for you? Respondents primarily indicated that the acquisition of new skills, social interaction with peers, the development of practical programming abilities, and robotics were the most satisfying aspects of the induction programme. P1 highlighted the satisfaction of “*Coding something and actually seeing it physically work. Working with others*”, whereas P17 mentioned “*Seeing the progress we all made during the two weeks. The time coding decreased, the time building decreased, and creativity*”

increased. Getting to know each other, I didn't know 80% of the class from the prior 3 years but got to know everyone now.”

Which two aspects of the induction programme stood out as least satisfying for you? The primary issues highlighted by the respondents are the long hours, the fact that the daily programme often starts early, issues regarding conflict with peers, and that some of the tasks started to become repetitive.

Describe the most important aspects that you learned during these two weeks regarding your technical skills such as: IT discipline/your knowledge/your skills. The necessity of applying practical programming skills and cooperative teamwork to problem solving, as well as personal discipline, are highlighted as skills that were sharpened. As stated by P12, *“Applying our knowledge to new challenges, communication, learning new approaches to solving problems”*, a sentiment that is emphasised by P18 who said that the programme helped to *“Sharpened my Python programming skills. Sharpened logical thinking and problem-solving skills. Learned the importance of clear communication and expectations in group work.”*

Describe any other aspect(s), not mentioned before, that you learned during these two weeks. The three main aspects that were specified by the respondents are a change in mindset from an undergraduate to a post-graduate perspective, the differences between undergraduate and post-graduate studies, and the importance of planning ahead. Of particular note is the response of P9, who said *“That in postgraduate people treat you differently, You're not just a number anymore. You're more like a colleague, and everyone tries to help where they can”*, and P18 who explained that *“I learned the importance of assessing your approach to a problem logically.”*

Name at least two aspects that you realised that you personally need to change or improve during/after the induction programme, to be more successful in your studies or career. Interpersonal skills, such as communication and conflict management, feature prominently with this question. Additionally, several respondents indicated that they need to work on managing stress and anxiety better, such as P14 who stated, *“I need to still handle my anxiety better”* and P1 who indicated *“Motivating myself and stress relief”* as aspects that needed improvement.

The following questions are included in the questionnaire as follow-up questions to quantitative questions. Some of these open-ended questions are directly related to the qualitative data presented in the previous section. The quantitative question is preceded for each of the open-ended questions.

To what degree were your expectations of the induction programme met? - Why did you say so in the previous question? Respondents who indicated that their expectations were not met mostly identified a lack of variety and challenge in the tasks as the primary cause. For those who indicated that their expectations were moderately met, the fun of the programme is presented as a positive, but found that the structure and contents of the programme were not what they expected; especially as it relates to information on the remainder of the honours year. Finally, students that were of the opinion that their expectations were completely met highlighted how well they were received and the challenging experience as positives.

To what extent is there a gap between the level/standard of your third year IT modules, and the IT modules in your honours year? - Why did you say so in the previous question? The most prominent causes for the gap, as identified by the students, are a much greater workload, the higher quality of work that is expected, and

that the subject matter is discussed in greater depth and detail. Respondents that indicated that the gap is small, attributed this to their passion for the modules they selected for their honours year.

To what extent did the induction programme help to alleviate the COVID isolation to get back into full face to face T&L mode and be in classes with other students? - Why did you say so in the previous question? This question, included to determine if students still experience the after-effects of the COVID lockdowns, mainly elicited responses that indicated that the return to full contact teaching had the greatest impact on reducing the impact of the lockdowns on academic performance. In fact, several respondents suggested that the impact is no longer an issue, such as P10 that said that “*COVID is not a problem anymore*”, and P17 who explained that “*The COVID isolation effect has been relieved according to me, therefore I do not see this as a problem anymore.*”

In summary, it can be seen from the responses that the induction programme is an effective tool in preparing honours students for their year ahead. However, more can still be done to better communicate the purpose of the programme to students, and to improve the contents and structure of the programme. In the next section, the paper is concluded with a broader consideration of the implications of these findings, and possibilities for future work are discussed.

6. Conclusions, Limitations and Future Research

The focus of this study is to reflect on the effectiveness of an induction programme for students pursuing an honours degree in computer science and information technology, and to gain insights into their experiences. To this end, two questionnaires were developed to collect anonymous feedback from current year (2024) honours students: the first questionnaire was sent out prior to the induction programme, whereas the second one was distributed a month after the start of lectures. The feedback obtained using these questionnaires shows that the induction programme is well-focused and effective in developing the important skills that students need for an honours year, and that students perceive the programme as useful. The usefulness is not only on a technological level, but also extends to soft skills such as creativity and time management. The students further learned about themselves and realized, for instance, that conflict resolution and stress tolerance should be further improved. However, the programme can be enhanced in several ways, such as improving the overall structure of the programme and incorporating a greater variety of tasks. The insight gained from this study is also useful for the facilitators to take note of for future endeavours, and to focus during the year on potential growth points to further enhance the employability and other attributes of the students.

There are several limitations to the study. Firstly, responses were not received from the entire group, making it difficult to firmly generalise the findings. Secondly, as the questionnaires are anonymous with no personally identifying information, it is not possible to match specific responses from the first and second questionnaires, nor is it possible to delve deeper into the academic background of the respondents. Lastly, as both of the questionnaires were distributed at the beginning of the year, it is difficult at this stage to predict the impact that the induction programme will ultimately have on the academic success of the honours students of 2024. Nevertheless, there is a high

level of confidence, based on the feedback received, that the induction programme had an overall positive effect.

For future work that follows on this study, an additional survey could be conducted after graduation to determine the perceived value of the induction programme following the completion of the degree, and perhaps also exposure to real-world working environments. A follow-up study, following the implementation of the improvements identified in this study, can also be considered to determine the scope of the improvements.

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Preparing Foundation Phase teachers in KZN to teach coding

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Abstract. The fast-evolving pace of technology demands an equally evolving workforce. This necessitates that education incites critical thinking, creativity, and problem-solving from the Foundation Phase. Coding is recognised as an evolutionary subject that lacks trained teachers. This research investigated how Foundation Phase teachers in a district in Kwa Zulu Natal can be prepared to teach coding, through unplugged coding training. This paper focuses on the preparedness of teachers after attending the training. The researcher observed an introduction to coding training workshop offered to Foundation Phase teachers with no or very little experience in coding. Six teachers from three schools from the province were sampled from a population of teachers who attended the workshop. They provided survey and focus group data. The data was analysed thematically, according to the Assessment of Education Technology Professional Development framework. This framework integrates organisational learning; participant and research inquiry; and the Technological Pedagogical Content Knowledge framework. Although it was found that teachers mainly still lacked the confidence to teach coding after the training, some of the positive findings were that teachers realised that coding was not too difficult to teach, could be related to other concepts taught, and is taught best through free learning and interactive play. Findings indicate that training can support individual knowledge development in terms of coding content, educational technology coding tools and Foundation Phase learning strategies such as play and active learning. But this can further be strengthened through utilising the concepts within the Education Technology Professional Development framework to develop individual learning towards organisational and life-long learning.

Keywords: Coding, Education Technology Professional Development Framework, Foundation Phase, professional development, TPACK.

1. Introduction

At the start of 2019, the South African Government, announced the development of a curriculum for coding and robotics for Grades R to 9, where coding is instructional lines for a computing device [1], and robotics involves machinery and actualising coding [2]. The Minister of Basic Education, Angie Motshekga, indicated that coding can help prepare learners for contributions towards sustainable industrialisation, and to keep pace with developments in the world [3]. She further explained that the

Department of Basic Education (DBE) was focusing on educational coding and robotics to foster the development of computational thinking skills.

This paper reports on some of the work done for an M Ed study on the preparation of Foundation Phase teachers to teach coding.

2. Background

As part of the Department of Basic Education's introduction of Coding and Robotics as a subject, the draft Curriculum and Assessment Policy statements Grade R-3 (Foundation Phase) was released on 19 March 2021 [4]. Since then, instead of the fact that most teachers have little or no knowledge of coding and robotics, various interventions have been rolled out in the country to facilitate the introduction of Coding and Robotics as a subject [5, 6].

Unplugged coding (in contrast to plugged coding) is an approach aimed at assisting with the introduction of "coding without using a computer" [7]. Tangible Africa, a partnership between Nelson Mandela University and the NPO Leva Foundation, is an initiative that aims to teach unplugged coding. The approach addresses various realities in schools such as lack of computers, electricity, and the Internet. The initiative further develops offline instruments that are cost-effective, to equip teachers without programming experience, to be able to teach coding [8, 9, 10]. The BOATS coding application and kit were developed by Tangible Africa, to package unplugged coding learning for the Foundation Phase, supported by a mobile application that is available as an offline tool.

Foundation Phase teacher-specific training, tailored to the BOATS unplugged coding app and kit, was developed by Kelly Bush from Hudson Park Primary School. BOATS unplugged coding training was offered to all Foundation Phase teachers around the country in 2021. The training was presented online, due to restrictions during the Covid19 pandemic. Kwa-Zulu Natal schools also participated in the training as part of the Department of Education's Teacher Union Collaboration project, orientating teachers towards coding and robotics in the classroom.

This research explored how the BOATS training could support the preparation of Foundation Phase teachers in Kwa-Zulu Natal to teach coding.

3. Problem Statement

The introduction of a Coding and Robotics curriculum is beset with varying challenges and problems. There is general concern over the following aspects:

Technology develops fast and it is difficult for teachers to keep up.

Recent research conducted at Stellenbosch shows that around half of the current public school teacher population is over the age of 55. This could explain why most teachers are afraid of educational technology, and feel intimidated by them [11, 12].

One of the elements of the 4IR is to prepare learners for Computational Thinking.

Computational thinking is a thought process of formulating problems and solutions and presenting the solution for execution by a computer [13]. Coding, a computational

thinking skill, solves problems through a computer-science problem-solving approach [14, 15]. Computational thinking is regarded by [16] as a way of thinking applied to solving problems, including programming tasks and computer science.

Introduction of coding (and robotics) from an early age.

Researchers agree that it would be beneficial to engage learners from an early stage in subjects dealing with technology, such as coding [17, 18, 19]. This highlights the need to introduce coding already in the Foundation Phase.

Professional development for teaching coding.

There seems to be a great deal of research into pedagogical approaches and professional development for teaching coding, and utilising various technological resources in teaching coding [20-24]. There is, however, a lack of literature on guidelines for preparing Foundation Phase teachers to introduce coding, resulting in a gap in professional development programmes for these teachers.

4. The teaching of coding in South African schools

In 2012, the United Nations held a conference known as the United Nations Rio+20. The conference committed nations to a new global sustainable development agenda which is aimed at being achieved by the year 2030. There are 17 universal sustainable development goals (SDGs) within the sustainable development agenda [24]. SDG 4 aims to ensure quality education that promotes lifelong learning [25]. Goal 4.4 particularly states that, by 2030, the number of youths with relevant technical and vocational skills should be increased.

The Department of Basic Education acknowledges that, to solve the problems of development arising from a fast-changing world, it must heed the call for a coding (and robotics) curriculum [3]. In working towards solving the problems of development in South Africa a National Planning Commission was appointed to draft the National Development Plan (NDP) in May 2010. Chapter 9 of the NDP outlines educational objectives that must be achieved by 2030. The NDP states that the key to overcome the legacy of apartheid is for everyone to have access to quality education. The Department of Basic Education's commitment to the NDP is outlined in the Action Plan to 2024, scripted in August 2020. It identifies six priorities, the second of which is the immediate implementation of a curriculum with skills and competencies for a changing world.

Turning to the primary level, the DBE completed a preliminary curriculum for coding and robotics for Grades R to 3, and Grade 7 in 2019. The piloting of this curriculum in selected schools began in 2020 [26]. The preliminary curriculum [4] has five overarching focus content areas or knowledge strands, namely: Pattern Recognition and Problem Solving; Algorithms and Coding; Robotics Skills; Internet and E-Communication Skills; and Application Skills. These five content areas have topics that converge and overlap. In instruction, for instance, Pattern Recognition and Problem Solving lend themselves to Algorithms and Coding, while the latter is needed for robotics. At the writing of this article, the final accepted curriculum has not yet been published.

5. Research Question

Parker [27] reminds us that primary school teachers tend to be generalist teachers, who are unlikely to have in-depth content knowledge, especially of science subjects (such as coding and robotics). Ingersoll [28] advises that, for proper educational reform to occur, education departments should avoid having teachers teach subjects for which they have little education or training. However, Williams, Williams and Kendal [29] understand that this may not be possible, as qualified Information Technology or Computer Science teachers would unlikely choose to continue in the education field, given the lucrative Information Technology careers that exist outside of teaching. This implies that most primary school teachers are not prepared to teach coding and robotics.

There is a visible gap in effective and rigorous professional development programs for teachers in implementing coding and robotics. This research aimed to find out how such a gap can be filled for the Foundation Phase teachers during training for unplugged coding. The main question for the MEd research was: *How can Foundation Phase teachers in KZN be prepared for teaching coding?*

This paper reports on the following sub-question from the research: *How do teachers' preparedness change during unplugged coding training?* Teacher experiences before, during and after the online BOATS training were utilised for the research.

6. Methodological Overview

This research was situated in the interpretive paradigm, as the teacher experiences of online training to teach coding to Foundation Phase learners through the BOATS app were investigated and interpreted [30]. The researcher incorporated the hermeneutic principles, proposed by Klein and Meyers [31] to ensure that the interpretation is a true reflection of the participants' experiences.

The approach to theory development was deductive, as the research moved from generalisations as packaged within a framework (for this study, the assessment of the effectiveness of the Educational Technology Professional Development model), to specific observations during the research [32]. The methodological choice for the research was qualitative. This allowed the researcher to obtain a deeper understanding of the views of participants on their preparedness to teach coding [33].

This research was conducted following the Action Research strategy [33]. Two cycles were implemented. The first cycle focused on observations during the training, while the second cycle relied on post-training surveys and focus group discussions. Data analysis was guided by the five stages of qualitative data analysis, as adapted from Denscombe [35]. These include the preparation of the data, familiarising with the data, interpreting the data (developing codes, categories and concepts), verifying the data (matching and reviewing themes) and representing the data. This was not a pure linear process, and stages were revisited often during the analysis process.

The researcher sampled six Foundation Phase teachers from three schools in Kwa Zulu Natal, who attended online BOATS unplugged coding training. The three sampled schools were within proximity of the researcher. In maintaining confidentiality, the teachers, along with their schools, were assigned codes in the data collection. Data was

collected through document analysis of the draft curriculum, observation, a survey and focus groups.

The appropriate processes were followed to ensure that the research was done in an ethical manner, according to the University of Pretoria and the Department of Basic Education approval processes. Ethical clearance and approval for the research was obtained from the university ethics committee, the Kwa-Zulu Natal education department and the headmasters of participating schools. Teachers provided informed consent to their participation in the research.

7. Theoretical underpinnings

The theoretical underpinnings for the study reside in the meaningful assessment of the effectiveness of Educational Technology Professional Development (ETPD) model of Borthwick and Pierson [36]. Three concepts underpin this model, namely the Technological Pedagogical Content Knowledge (TPACK) framework, the Organisational Learning theory, and the Participant Research and Inquiry. Figure 1 depicts the Assessment of ETPD model as adapted for this study.

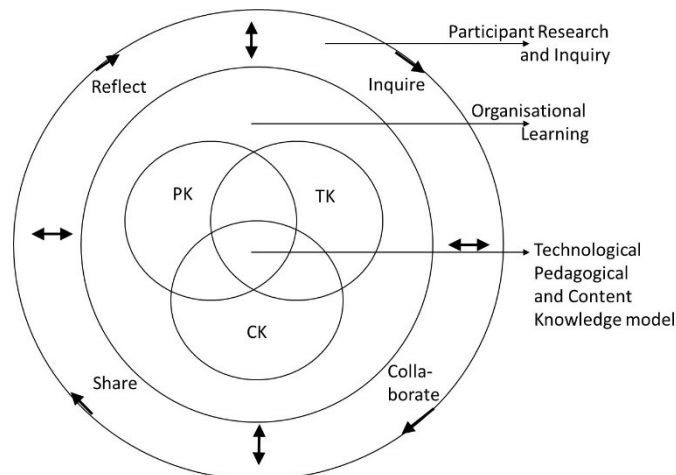


Fig. 1. Assessment of ETPD model Adapted from Borthwick and Pierson [36]

The **Technological Pedagogical and Content Knowledge Framework** resides at the centre of the framework. It aims to describe the meaningful integration of technology in teaching and learning [37, 38, 39] and is focused on individual teacher knowledge. It was applied as follows in this study:

1. The pedagogy knowledge in this research, is the method and practice of teaching coding, comprises the teaching strategies and theories implemented in the training of teachers, and is proposed for teaching learners in the FP.
2. The technology knowledge in this research, describes the technologies utilised during the training and teaching, such as the online environment for virtual training, as well as the app/s utilised in the process.

3. The content knowledge in this research, is the coding content included in the curriculum for the Foundation Phase learners.

The **Organisational Learning Theory** is the next layer in the framework. This layer focuses on the creation and use of the TPACK knowledge within an organisation, by transferring individual learning to that of an organisation through people interacting and solving a problem [40]. Brindley et al. [41] note that research can contribute to practitioners' thinking. Organisational Learning is a term introduced in the 1970s by Chris Argyris and Donald Schön [42] to describe a process involved in the transfer of learning from an individual level to that of an organisation [43]. Leavitt [44] explains three organisational learning theories:

1. Experiential Learning Theory, suggested by Kolb [45] as described by Leavitt, explains stages of experience as fundamental processes for organisational learning. The stages are summarised into two. These are those that represent the grasping component (concrete experience and abstract conceptualisation), and the experienced component (reflective observation and active experimentation).
2. Adaptive and Generative Learning Theory inspired by Peter Senge [46] as described by Leavitt, lists the five traits required for organisational learning to occur. These are personal mastery, building shared vision, team learning, and systems thinking.
3. Assimilation Theory by DiBella, Goulds and Nevis [47] as described by Leavitt, indicates that organisational learning will occur in the three stages of acquiring knowledge, sharing knowledge, and using that knowledge.

In this research, individual learning is identified as transferred to organisational learning, as teachers create a culture of engaging with the technical, pedagogical and content knowledge of coding, after taking part in the training workshop and engaging with the researcher. This process occurs over and over again, as teachers and their research partners engage in the Action Research process within the organisational context.

Participant Research and Inquiry is the outer layer of the ETPD framework. This layer focuses on a variety of ways in which individuals and groups reflect on their practice, for the purpose of evaluation and feedback as a form of lifelong learning and professional development [48, 36]. When teachers do so, they are, as researchers, constantly asking questions about their teaching; collecting and analysing multiple forms of data and collaborating with one another to inform future teaching plans. "Promoting lifelong learning means enabling students to monitor the cohesiveness of their ideas and their progress in understanding. When students are prompted to reflect, they analyse their progress" [48] In other words, the approach of participant research and inquiry to the evaluation of professionals allows for teachers to gain lifelong learning through the research.

Participant research and inquiry happened in this research through participants engaging with each other, and the researcher asking questions about teacher experiences in learning the teaching content (inquire), coupled with their experience in teaching the content (sharing); collecting and analysing multiple forms of data (reflecting on the teaching), and collaborating with one another to inform future teaching plans in the implementation of the coding curriculum (collaborating). In this process of lifelong learning each phase impacts continuously on the next – as illustrated by the arrows in this layer in Figure 1.

The bi-directional arrows between the Organisational Learning layer and the Participant Inquiry layer illustrated how these two layers are continuously impacting each other through inquiring, sharing, reflection and collaboration.

8. Results and Findings

The research question that this paper focuses on is “*How do teachers’ preparedness change during unplugged coding training?*” The original treatise [49] provides a detailed discussion on how data was collected and analysed. This section provides an overview of some of the findings for this question. The section is structured according to the three theoretical concepts that underpin the ETPD framework [36] as illustrated in Figure 1.

8.1. Technological Pedagogical and Content Knowledge

The TPACK [38] model is at the centre of the ETPD [36] framework and focuses on individual knowledge development. The research findings strengthen and expand on the specific nature of each of the three bodies of knowledge as provided by literature in preparing to teach coding in the following manner:

Technological Knowledge: Participants revealed that teaching coding requires *new technological teaching and learning strategies*. Teaching coding is teaching critical thinking, and therefore, it needs the *learner to be engaged and actively participating*. They also noted that teaching coding calls for a teacher to *utilise various resources* for concept illustration.

Pedagogical Knowledge: Findings that correspond to literature include *that teaching coding in Foundation Phase requires free-play learning*, as advised by the draft CAPS document [4]. In lieu of that, the teachers felt that *coding needs extensive planning to be taught*, and *more time allocation* for teachers to teach coding given its pedagogy. They also felt that *unplugged coding meant coding could eventually be easily learnt*.

Findings that offered a different view from the literature and were not highlighted in the theoretical framework is that the participants’ views on being prepared to teach coding changed during the BOATS coding training course as they *debunked the misconceptions of coding being difficult*. The teachers felt *coding concepts can be related to concepts taught in other subjects*, for example, sequencing in English. The research findings indicate that this would strengthen the pedagogical knowledge needed to teach coding in the Foundation Phase.

Content Knowledge: The findings revealed that there was still *confusion as to what coding really is*, as the scope of understanding its practical component was not one the participants had witnessed. The teachers continued to refer to the BOATS application as a game, rather than a concept for teaching basic coding skills because they had not yet implemented coding skills practically. The teachers *noted the concepts* they have learned from the course, which are the main themes in coding, such as critical thinking, creativity, learning to give instructions, sequencing and problem solving.

The findings that offered a different view from the literature review and not highlighted in the theoretical framework are that it was noted that participants *lacked*

confidence to teach coding because of a (perceived) lack of content knowledge for teaching coding.

8.2. Organisational learning

Organisational learning [40] is the next layer in the ETPD framework, focusing on how individual learning can be transferred to and supported by organisational learning. Two teachers from the same school noted in the surveys that the *involvement of management encouraged their confidence* in learning to teach coding and teaching it extramurally. *Decisions about teaching coding were taken through sharing, collaborating, and organisational initiative.*

This finding strengthens two of the three Organizational Learning theories mentioned in Section 7. First is the Adaptive and Generative Learning Theory [46] which lists personal mastery that builds shared vision, team learning, and systems thinking as the traits required for organisational learning to occur. The second is the Assimilation Theory [47] which indicates that organisational learning will occur in the three stages of *acquiring knowledge, sharing knowledge, and using that knowledge*, as also observed in the findings.

8.3. Participant research and inquiry

The outer layer in the ETPD framework focuses on transferring organisational learning into life-long learning [48, 36]. Emerging from the data is that the teachers realised from the training course that *teaching coding requires teacher reflection. A teacher needs to be adaptive* to the fast-changing world and technologies. The instructor made references to various coding platforms during the training, even though the training was about the BOATS application. This indicates the *knowledge of multiple platforms of coding* required for the coding teacher to understand. Thus, *constant sharing* is needed *between teachers*.

The teachers' preparedness during unplugged coding training didn't quite change, but data rather suggests that they *became more aware of the scope of change they need to undergo* in their TPACK and that needs to occur within their organisations in order to teach coding.

What the BOATS unplugged coding training sparked for the teachers is the Participant research and inquiry layer, was teacher *reflection, sharing, enquiring*, whether positive or negative, into their readiness to teach coding. The course also sparked teacher realisation that *learning to teach coding requires more than just a course* for teachers. This was strengthened for those teachers who continued to actively teach coding after the training, whilst supporting each other through reflection and inquiry.

9. Conclusions

With the new Coding and Robotics curriculum being rolled out in South Africa over the next year or two, a major challenge is the unpreparedness of most teachers in the system. It is thus critical to find ways to train and empower these teachers.

This paper reports on M Ed research conducted on the role unplugged coding training could play to address the above-mentioned reality. Findings show that, after

the training, teachers still showed some confusion regarding what coding really is. They failed in seeing the link between the unplugged coding taught, and “actual” conventional coding. This had an impact on their confidence levels. It was, however, also found that some positive impact could be observed. While they still lacked confidence, there was a realisation that coding was not too difficult to teach, could be integrated into other concepts taught and is best taught through free learning and interactive play. Furthermore, the successful teaching of coding was also directly linked to the support received from management in a school.

The findings indicate that cognisance of the concepts and interactions between concepts in the ETD framework can positively impact a more holistic approach to preparing teachers in the Foundation Phase to teach coding. This implies firstly a conscious preparation for relevant TPACK development during training in content (coding according to the curriculum), learning strategies (play-based and active learning), technology (understanding the software as a tool to teach coding) and their interactions. This can be strengthened through an organisational environment and support where the TPACK individual learning can be further developed towards organisational and life-long learning through continuous inquiry, reflection, sharing and collaboration.

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Navigating the Integration of Chatbots in Education: A Case Study on Source Code Plagiarism

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Abstract. Since its emergence late in 2022, chatbots like ChatGPT, Bard and Gemini brought about a notable transformation in the educational landscape. This shift necessitates adjusting the methods employed for education, aligning with the rise of generative artificial intelligence tools. Central to this transformation is the pivotal inquiry regarding how these tools should be seamlessly integrated to facilitate essential skill acquisition while concurrently elevating these very skills. In the context of first-year computing students learning Python programming, this study delves into an exploratory investigation which specifically examines the scripts of a cohort of 145 students. The primary aim is to gauge the level of involvement exhibited by these students in employing ChatGPT and to chart a prospective course for their guidance, focusing on the adept utilization of such tools. The goal is to equip students with the potential to extend their capabilities with the help of generative artificial intelligence. Findings indicate a notable deficiency in students' proficiency in using chatbots. Several indicators direct the researchers toward the proposition of integrating a chatbot as an instructional instrument, with the potential to enhance the envisaged learning outcomes. Including generative AI tools should be approached with caution, particularly since chatbot application extends to generating solutions for challenges that fundamentally demand students' active problem-solving engagement. Surrendering the responsibility of problem-solving to the chatbot could undermine the very essence of acquiring coding skills, especially among novices in the art of coding.

Keywords: Artificial intelligence-based teaching and learning, chatbot, Measure of Software Similarity (Moss), the programmer of the future.

1. Introduction

This study delves into the realm of generative artificial intelligence, focusing on the role of the poster chatbot – ChatGPT – among a myriad of similar tools, such as Gemini, DALL-E, and Bard, as a potential learning tool. ChatGPT's strength lies in generating text, but an aspect often overlooked is that ChatGPT is also an excellent generator of programming code, since it has access to GitHub libraries, and has been trained on millions of lines of code. Parallel to this notion, text-based plagiarism detection mechanisms like Turnitin have been tailored to identify text originating from ChatGPT, albeit with some associated problems. Not so well-known is whether this is also the case in the coding context.

Conversely, a significant facet to contemplate is the potential for students to harness tools like ChatGPT to augment their skill sets and expedite workflow, to transcend the bounds of proficiency and increase productivity in the programming academic environment and workforce. Central to this impression, is the underlying premise that mastering coding should precede utilizing tools to assist the coding process. Alternatively, one might question the relevance of this premise in a milieu where adept chatbots stand ready to assist human operators.

This paper explores these issues by examining the programming scripts of a cohort of students enrolled at a South African university. This critical examination will follow a process delineated within the paper.

It should be noted that the participating students are predominantly from disadvantaged communities where a very small percentage of students are exposed to programming at secondary school. Upon analysis of the data and extraction of insights, this study offers valuable recommendations concerning the optimal path forward in imparting coding skills to novice programmers within the context of available chatbots.

Section 2 focuses on extant literature relating to chatbots in general, ChatGPT, Measure of Software Similarity as a tool, the teaching of novice programmers, as well as what the world of future programming might entail. Next, the research design includes the research methodology, the environment in which the study was conducted, and the approach followed (Section 3). Following this, the analysis of the data is addressed regarding the implementation of the suggested process (Section 4) and reflecting on the students' views on key issues (Section 5). Findings and recommendations follow in Section 6, and the study is concluded in Section 7.

2. Theoretical grounding

A summary of relevant literature that underpins the scope of this study is provided. It encompasses several crucial facets, including the functionalities afforded by ChatGPT, the mechanics of the Measure of Software Similarity (Moss) software tool, essential aspects when teaching novice programmers, and finally, the utility and examination of the future landscape of programming alongside the characteristics that may define the future programmer.

2.1. ChatGPT as chatbot

In a rapidly evolving technological landscape, the emersion of smart machines embedded with cognitive technologies such as generative artificial intelligence (AI) and machine learning, is reshaping our world. Among these technologies, generative AI stands out. The underlying AI and machine learning algorithms empower machines to interpret and produce high-quality content in the form of text, audio, images, videos, and code. Currently, this innovation is getting much attention across various sectors, positioning itself as a crucial asset for organizations in today's business world [1].

ChatGPT stands out among the list of current generative AI tools, and two versions are available, namely a free-to-use version – ChatGPT 3.5 (GPT3), released in November 2022, and a paid version, ChatGPT 4.0 (GPT4), released in March 2023. According to OpenAI [2], GPT4 is "10 times more advanced" than GPT3, and boasts

several enhancements, with the key differences being in terms of the complexity and multimodal capabilities.

Generative AI offers a range of benefits, such as improved productivity through task automation, reducing barriers related to skills and time in content creation and creative pursuits, facilitating the analysis of data, and providing synthetic data for training and refining other AI systems, thus contributing to improved performance and versatility [3]. Unfortunately, generative AI also presents a set of challenges, including hallucination – where models, such as the less trained free GPT3, generate nonsensical content [4], a dependency on data labelling with concerns about data quality and low-paid human labour [5], difficulties in content moderation which requires human intervention to filter inappropriate material [6], ethical dilemmas due to algorithmic bias and discrimination [7], legal and regulatory issues related to copyright, privacy, liability, and political implications which involve misinformation and interference in democratic processes [8], as well as environmental concerns due to significant energy consumption by AI models [9].

2.2. Measure of Software Similarity

Source code plagiarism (SCP) occurs when a script is copied from another script with a small number of, or no, routine modifications [10]. Modifications may vary in sophistication to range from simple changes to comments, intermediate changes to amend formatting, add declarations, statements, or superfluous variables, to advanced changes in program modules, program statements, and decision logic – which means that the significance of changes lies in the fact that simple changes require limited programming knowledge, while advanced changes require high levels of programming expertise [11, 12]. Therefore, novices who replicate source code to resolve elementary problems undermine the fundamental purpose of acquiring coding skills. On the opposite end of this spectrum, experienced programmers typically write intricate scripts to address complex problems using limited-acquired code. This explanation leads to a multi-layered definition of SCP, with the latter part of the deliberations applicable to senior students in an educational setting, or experienced programmers coding in a work environment [13].

The advent of chatbots allow a student to obtain a solution that is fully generated and not easily recognised as plagiarised, which may exacerbate SCP and defeat the purpose of learning to code – which is necessary to utilize chatbots effectively.

With text plagiarism being a persistent problem in academia, tools such as Turnitin and Grammarly are usually used to identify it in academic writing [14]. Unfortunately, these tools do not accommodate SCP detection, and specialised tools such as Moss, Codequiry, and CodeLeaks are required for detecting SCP [15].

For this study, Moss was utilized since it is a freeware tool, but it is important to note that it “*is not a system for completely automatically detecting plagiarism*”; it “*detects structural similarities in programs and nothing more*” [16]. Moss is excellent in identifying matching snippets of code, but it will exclude code that appears in too many of the submitted scripts. This results in all matches reported by Moss, to accurately approximate the signature of plagiarized code; it is a snippet of similar code in two scripts that does not also appear in many other submitted scripts. Measure of Software Similarity has no opinion as to why programs may be structurally alike. Therefore,

results from Moss cannot be used as evidence of plagiarism – it is necessary for a knowledgeable person to examine the scripts – to make a judgment.

2.3. The novice programmer as a learner

In the first semester of the first year of learning to code, Python 3 is the tool used to teach programming. Since Python is an interpreted language, one can run simple Python expressions and statements in an interactive programming environment, the shell, with the tool of choice being The Integrated Development Environment (IDLE) – to be used with the Python installation [17]. In the prescribed outcomes of the module under discussion, only the basic constructs of programming, namely sequence, selection and iteration are focused on. The purpose is to make sure students understand these constructs well and that they can solve problems from a programming perspective, regarding the three constructs, and their integration [17].

2.4. The programmer of the future

Research from educational psychology suggests that teaching and learning are subject-specific activities [18], and therefore programming requires a different teaching and learning approach [19]. With the advent of AI, chatbots are changing the playing field at an accelerated pace, transforming the landscape of teaching and learning, specifically the teaching and learning of programming skills. Generative AI tools are anticipated to have a significant impact on shaping the job market. When used effectively, they have the potential to transform future graduates into employees equipped with capabilities enhanced by generative AI. Whilst these tools streamline tasks, they can also provide complete coding solutions for smaller problems – a facet crucial within the scope of this paper.

Computer programming skills are at the heart of technological advancement across all disciplines and by extension a necessary skill for both economic growth and national development. Learning to code is fundamental for programming. Coding is the primary skill required for building robust, scalable, and secure software applications. Coding is the backbone of technological advancement. From mobile applications to AI, from the Internet of Things to blockchain, every technological breakthrough relies on code, and technology is integrated with all disciplines. Students must apply logical thinking and problem-solving skills to translate ideas into functional software. Thus, syntax, semantics and the logic of the coding language must be understood to convert human-readable instructions into machine-executable commands.

The problem that all educators in the field of technology face is how programming and learning to code will change in the future. Predicting the future of programming and learning to code is inherently challenging, but there are several trends and potential developments predicted by experts, such as Welsh [20], CEO and co-founder of Fixie.ai, predicts that the focus on self-learning would receive more emphasis. It will become increasingly important to understand the advantages as well as the limitations of generative AI tools [21]. Trying to prohibit students from using these tools is not desirable nor can it be policed all the time. We also need to prepare them for the world of work where the responsible and correct use of these tools will become a competitive advantage. In support of using these tools, McKendrick [22] predicts that AI will be increasingly used for software development work, implying that developers may eventually be working with training models rather than they do with coding tools. In a

large-scale survey Meyer, Fritz, Murphy and Zimmermann [23] found that generative AI enables developer productivity beyond speed; they found that 60–75% of the users reported more job fulfilment, fewer frustrations when coding, and preserving mental effort during repetitive tasks. As an added advantage, generative AI will not only create new applications but enhance existing ones [24]. Ito [21] reported on a study where software developers were divided into groups, where one group had access to ChatGPT which was trained on a larger code repository, whilst the other group did not. Those assisted by AI completed their task 56% faster than the control group. Thus, when using AI as a support tool we can indeed produce efficient programmers and turbocharge programming.

Therefore, while keeping a changed work environment in mind, teaching students of the future to code in our fast-changing world requires innovative strategies that not only introduce students to coding languages and concepts but also foster time management and stimulate creativity and critical thinking. New trends that can be brought into the teaching of coding are the introduction of virtual and augmented reality coding experiences through the use of virtual and augmented reality technologies, with the purpose of creating immersive and interactive experiences which make abstract coding concepts more tangible and easier to grasp [25]. Augmented reality, where digital content is overlaid onto the real world, creates an immersive and interactive experience that enhances how users perceive and interact with their surroundings by blending virtual elements with physical environments. Salunke [26] suggests gamified learning platforms to facilitate interactive coding games to assist in shaping the future generation of innovators and problem solvers.

Karnalim and Chivers [27] used gamification to sensitize and educate students about SCP and found that through these games, students became more aware of programming plagiarism and collusion, completed assessments earlier, and read generated reports more frequently. Organizing coding clubs and hackathons where students can collaborate, share ideas, and work on coding challenges may instil a sense of community and competition, driving students to excel in coding [28]. In addition, the implementation of a system of micro-credentials and badges for completing coding milestones or mastering specific skills, which incentivizes students to set and achieve short-term goals and build confidence in their abilities. Tamoliune, Greenspon, Tereseviciene, Volungeviciene, Trepule and Dauksiene [29] stress that micro-credentials can provide a perspective on and a targeted way to clearly validate competencies and facilitate employability. The multidisciplinary nature of software development will increasingly demand future programmers to work in multidisciplinary teams where subjects such as art, music, science, health or business intersect [30].

3. Research design

In this case study, a mixed-method approach was employed to capture, reflect upon, and make sense of the scripts under discussion. At the end of the semester, students were invited to complete an online questionnaire, aiming to provide the lecturer an improved understanding of students' perspectives on SCP and their approaches to completing assignments. The main source of data was the written coding solutions or

scripts submitted by students in response to five distinct assignments, each comprising more than one problem.

3.1. Data of students selected as participants

The 2023 enrolment in the module, Introduction to Computing and Programming, comprised close to 1000 students. Students are spread across four campuses and were accommodated in seven classes. This study focuses on a cohort of 148 students enrolled in one of the classes. The module has a dual focus, it covers theoretical work, as well as practical work. Practical work includes MS Excel and Python programming, with the focus of this paper being the latter.

From the start of their studies, students are made aware of plagiarism, as well as the university's stance towards it. It should be noted though that the introduction of Generative AI tools came as a surprise to educational institutions, which did not allow the preparation of a corporate stance which coincided with its release.

3.2. Tools in support

In addition to the software tools already described and used to teach Python, two software tools were pivotal in conducting this experiment; GPT3, which was used firstly to generate code solutions to assignment problems to compare to student scripts, and secondly to identify code generated by it, and Moss, SCP detection software which was already used during the subject module's offering to make students aware of them being involved in SCP, were used once more to investigate whether students made use of ChatGPT to generate code on their behalf.

These tools were selected in favour of similar tools; GPT3, instead of GPT4, and Moss instead of tools such as Codequiry or CodeLeaks, because of their freeware nature. In addition, it is anticipated that, in the case of ChatGPT, students use the freeware version rather than the paid version.

3.3. A process as approach

Several steps were followed in determining whether students used ChatGPT for code generation:

- 1 The preprocessing of scripts entails the cleaning of Python scripts.
- 2 The student scripts were scrutinized to uncover indicators of resemblance to ChatGPT-generated code.
- 3 ChatGPT was prompted to generate coding solutions to the problems included in each assignment.
- 4 The assignment script directories were submitted to Moss.
- 5 Finally, an evaluation was conducted to determine whether ChatGPT could ascertain instances where it had provided a particular script solution.

4. The process implemented

The lecturer scrutinised the student and the ChatGPT generated scripts. Doing this was a learning exercise since many issues on the study's focus were observed, with these relayed in the discussion of the steps. The steps, as listed in the previous section, have been followed, and implemented as follows:

4.1. Step 1

Five formative Python assignments formed part of the assessment design. For each one a directory was created to store the resulting scripts submitted by the group of students as solutions to the two or three problems included in a particular assignment. These directories were cleaned and used earlier in the semester – to detect SCP among peers, also using Moss. The number of scripts received per assignment is relayed in Table 1.

Table 1: Number of scripts received per assignment, combined with ChatGPT scripts.

Assignment	1	2	3	4	5	TOTAL
Focus	Sequence	Sequence	Decision	Iteration	Integration	
Problems	2	3	3	3	3	14
Participating students	98	108	115	106	102	529
Student scripts	207	317	344	319	245	1432
ChatGPT scripts	5	9	12*	9	9	44
SCRIPT TOTAL	212	326	356	328	254	1476
Scripts with breaks	0	0	0	15	11	26
Scripts as chatGPT	10	0	1	9	1	21

4.2. Step 2

The scripts were scrutinized by the lecturer to identify issues that may provide clues regarding similarities with ChatGPT-generated code, such as:

- While students were guided not to use the break statement in their scripts, ChatGPT includes break statements in solutions. All student scripts containing a break statement were indicated as such by adding the word “break” to its name.
- Any constructs used in a script, not covered at that point in the syllabus, were highlighted by adding the word “ChatGPT” to its name.

4.3. Step 3

For each assignment problem, ChatGPT was asked to produce a corresponding script as a solution to the problem. Each prompt was the problem as it was given to students. Three scripts were obtained by the researchers, using two distinct ChatGPT accounts – for each problem. Through this action, three different script solutions were obtained from ChatGPT. In addition to these scripts, the researchers requested three more scripts from ChatGPT, only for Assignment 3-3, by engineering the prompt according to three requirements; (1) the solution should reflect the script of an expert programmer, (2) the solution should reflect the script of a novice programmer, and (3) the solution should not make use of functions. The exact same script was provided for

points 1 and 2 above, possibly due to the simplicity of the problem. These two solutions did make use of functions, while the solution correlating with point 3 did not.

The ChatGPT scripts were copied and saved as Python scripts to ensure that Moss recognises it as Python scripts. All the scripts were also tested to ensure execution. The scripts were included in the directories, with each corresponding assignment, to allow Moss to compare them to student scripts.

4.4. Step 4

The five directories were individually submitted to Moss, to produce a similarity report per assignment. Similarities between peers were already generated during the first semester – to make students aware of their work being identified as dishonesty cases – to create awareness of SCP among peers.

Similarities between students and ChatGPT were the focus of the current submission. The numbers are exposed in Table 2. Each row represents an assignment, including all the problems included in the assignment. Column “scripts included, from Table 1” includes the students’ scripts, as well as the ones generated by ChatGPT, column “similar pairs identified” shows the script pairs indicated by Moss to have similarities. To reflect the way Moss identifies similarities, namely the number of similar lines, and a percentage allocation with regards to the full script, four categories were formed (highlighting is used to show the severity of the similarity):

1. Less than 10 lines are similar, and less than 50% similarity is indicated.
2. Less than 10 lines are similar, and 50% or more similarity is indicated.
3. Ten or more lines are similar, and less than 50% similarity is indicated.
4. Ten or more lines are similar, and 50% or more similarity is indicated.

Column “number of scripts” indicates how many occurrences per assignment were found. The last column, “notes” informs Step 5. It is worth noting that the criteria outlined here, which were used to identify possible ChatGPT-generated scripts by scrutinising them for specific constructs, did not show a high correlation with the list generated by Moss. This re-affirms the lecturer’s suspicion that an electronic tool like Moss would be necessary for accurately identifying scripts generated by ChatGPT.

Table 2: Moss submission numbers

Assignment	Scripts included, from Table 1	Similar pairs identified	Number of scripts	Similar number of lines	Percentage similarity	Notes
1	212	151	0	1-9	less than 50%	Because of the simplicity of the problems, these results were not considered.
			4	1-9	50% or more	
			0	10 or more	less than 50%	
			0	10 or more	50% or more	
2	326	370	1	1-9	less than 50%	

			3	1-9	50% or more	No critical similarity level.
			0	10 or more	less than 50%	
			0	10 or more	50% or more	
3	356	300	7	1-9	less than 50%	One script with critical similarity (13 lines, 54%).
			1	1-9	50% or more	
			1	10 or more	less than 50%	
			1	10 or more	50% or more	
4	328	187	3	1-9	less than 50%	Three scripts with critical similarity, example (11 lines, 54%).
			1	1-9	50% or more	
			6	10 or more	less than 50%	
			3	10 or more	50% or more	
5	254	61	4	1-9	less than 50%	Two scripts with critical similarity, example (13 lines, 62%).
			0	1-9	50% or more	
			4	10 or more	less than 50%	
			2	10 or more	50% or more	

From the data similarities between student scripts and those generated by ChatGPT are shown to be limited. This may indicate that students did not rely much on ChatGPT to guide their code-learning journey. The highest percentage perceived is indicated as 62%, compared to similarities regarding SCP only, showing percentages as high as 98%; with the latter percentage proof of students relying heavily on peers. The lecturer anticipated that students might obtain ChatGPT scripts, but no evidence could be found to support this a suspicion.

One may wonder whether Moss is not capable of identifying ChatGPT reliance. This is debatable since Moss indicated similarities between different ChatGPT-generated scripts, with similarity percentages as high as 69%, confirming that different scripts generated by ChatGPT indeed show similarities on the Moss radar.

4.5. Step 5

ChatGPT was asked whether it supplied the script solution to each of the three categories discussed in Step 3. The replies received from ChatGPT are indicated in Fig. 1. This step established the fact that ChatGPT could identify code generated by it.

<p>Upon supplying the second ChatGPT generated script, requested by one researcher – of Assignment 4-3 – to ChatGPT, along with the question: “Did you generate this”, the answer relayed here, was received:</p>	<p>Upon supplying the third ChatGPT generated script, requested by the other researcher – of Assignment 4-3 – to ChatGPT, along with the question: “Did you generate this”, the answer relayed here, was received:</p>
<p>Yes, the script you provided was generated by me, ChatGPT. This script demonstrates a well-organized program that calculates the circumferences of different shapes based on user input. It follows a more structured and idiomatic coding style, using functions to encapsulate the logic for calculating circumferences and a main loop for interacting with the user. The use of the <code>if __name__ == "__main__":</code> block at the end of the script is also a common practice in Python to allow the script to be both imported as a module and run as a standalone program.</p>	<p>Yes, the script you provided was also generated by me, ChatGPT. This script demonstrates a simple loop that repeatedly asks the user for their name and then calculates and prints the circumferences of different shapes (circle, square, rectangle, triangle) based on user input. The script uses the input values to calculate circumferences and then formats and prints the results using string formatting. This script follows a more concise and direct approach compared to the previous one. It loops indefinitely to gather user input for each shape and calculates the circumferences accordingly.</p>
<p>Upon supplying the model answer of Assignment 4-3 to ChatGPT, along with the question: “Did you write this”, the answer relayed here, was received:</p>	
<p>No, I did not write that specific script. However, I can confirm that it is a program written in Python to calculate and display the circumferences of different shapes based on user input. The script utilizes the math library for the value of π and follows a procedural approach to achieve its functionality. It prompts the user to input the required parameters for each shape and then calculates and displays the corresponding circumferences. The script appears to have been manually crafted rather than being generated by an AI model. It follows a more standard coding style, which is consistent with code that is typically written by humans.</p>	

Fig. 1. Did ChatGPT recognise the scripts it generated?

Following this, three random student scripts were supplied to ChatGPT with the question “*Did you generate this Python script?*” posed along with each script. ChatGPT confirmed the finding of the previous step, that it did not generate the scripts listed.

5. Student views

The questionnaire, in part used to inform specific concerns relating to this study, allowed students an equal opportunity to participate anonymously and rendered 53 responses. Due to the sensitive nature of the information ethical clearance was obtained to conduct the research. A four-point Likert scale was used where students had to reflect on statements regarding topics relating to the investigation relayed in the previous section. Three statements are of particular interest in this context, namely (1) students’ use of learning resources, (2) their motivation to study, and (3) their SCP awareness. The distribution of the responses is summarized in Table 3, Table 4 and Table 5.

The responses indicate that most students (69%) use additional resources during learning to code.

Table 3: Student responses regarding the use of resources

Statement	Priority (low – 1; high – 4)			
	1	2	3	4
I research and use relevant resources to enhance my understanding of Python concepts and techniques (R1)	2%	5%	24%	69%
I seek assistance from tutors when facing challenges in writing my Python program (R2)	19%	19%	24%	38%
I collaborate with peers when facing challenges in writing my Python program (R3)	7%	29%	21%	43%

Only 38% of them use of tutors whilst a substantial percentage (43%) regard collaboration as a high priority, juxtaposed with only 7% regarding collaboration as a low priority. In Table 4 students' responses regarding their motivation to study are summarised.

Table 4: Student responses regarding their motivation to study

Statement	Priority (low – 1; high – 4)			
	1	2	3	4
I prioritize learning and understanding over completing assignments quickly by copying code (M1)	40%	5%	7%	48%
I actively seek to develop my coding skills and knowledge instead of relying on copying code (M2)	2%	26%	10%	62%
I document my thought process and explain the code I write to demonstrate my understanding and original work (M3)	7%	24%	36%	33%
The main priority is to pass this course; I will copy code if it means I can earn the marks (M4)	93%	5%	2%	0%
I do not copy source code because I rather want to learn the skills and be well-prepared (M5)	2%	7%	17%	74%
I do not copy source code as I fear getting caught (M6)	29%	10%	12%	50%

From these findings, it becomes evident that students do not necessarily see assignments as part of the learning, but rather a task to be completed. It is alarming that less than half of the students (48%) prioritize learning and understanding over completing assignments quickly by other means such as copying code. The responses also reveal that SCP detection mechanisms serve as a deterrent. Documenting thought processing during coding is another aspect that deserves more attention.

From the responses in Table 5, it is clear that students are aware of source code plagiarism and the consequences associated (95%), although many have not read the university policy (38%) and very few (7%) have attended any form of training.

Table 5: Student awareness of SCP

Statement	Priority (low – 1; high – 4)			
	1	2	3	4
I understand the consequences of plagiarism and the importance of maintaining academic integrity (A1)	0%	2%	2%	95%
I have read the university policy on academic integrity (A2)	26%	24%	12%	38%
I have participated in an academic integrity workshop or training session (A3)	55%	17%	21%	7%
It is fine to use source code that is freely available as long as I understand what the code is doing (A4)	40%	38%	12%	10%
Collaborating with peers to develop a code solution and then submitting similar work is acceptable (A5)	81%	12%	7%	0%
Using code snippets from online resources and incorporating them into your work is acceptable (A6)	67%	21%	7%	5%

Responses A4 –A6, and especially the latter two are reasons for concern, but it does indicate students’ need to learn by example.

6. Findings and recommendations

Student responses indicated that they do not view assignments as part of learning, but a task that needs to be completed, and they need and would use additional resources while coding. Awareness regarding relying on source code plagiarism to code and pass programming modules, and the associated impact should be addressed – to make students aware of responsible coding practises. More guidance should accompany assignments to include documenting thought processes during coding as this may facilitate learning to code. The unexpected result of not finding conclusive evidence of the use of generated code from ChatGPT, and in essence, any generative AI tool, is convincing in the argument as to whether students should be guided in the use of generative AI tools in future. Students who are motivated to study, and aware of SCP and its implications, can navigate learning in the digital era to allow them to excel in skills acquisition. In literature about the future programmer, it is indicated that programmers will produce code faster, with the help of generative AI, and surely this scenario needs to be simulated in an educational setting.

To facilitate such a scenario, ChatGPT may be valuable in acting as an online assistant to provide debugging assistance, bug prediction, and bug explanation to help solve programming problems [31]. Students should be guided in using generative AI for this purpose, to make provision for hallucinations, and to ensure that prompts are provided to obtain the desired results. In addition to assistance in debugging code, generative AI may assist in answering questions related to writing code, since ChatGPT will explain code even without explicitly asking for an explanation. Creative ways, such

as gamification can be employed as training platforms. It might be valuable to build some assignments around a basic problem, and then request students to reach out to ChatGPT to recommend improvements, which may allow students to apply cycles of improvement to their solutions, which may, for instance, also include checking for suitable data to be entered, which would produce a more robust product. Asking students to reflect on their learning in this context, may facilitate their understanding. Creating individual chatbots to facilitate the learning of computing theory is enticing in the context of teaching first years.

When considering the risks associated with AI, an opportunity exists to teach ethical coding practices and emphasise this aspect by detecting unethical practices. In addition, students should be made aware of included biases in AI algorithms which should be addressed. With the integration of technology in all walks of life, coding might become an essential skill in disciplines beyond traditional computer science, meaning that institutions of higher learning should accommodate this trend. Furthermore, with the advent of generative AI, it is anticipated that programming will become less dependent on humans. Consequently, programming education should also focus on the acquisition of soft skills, such as collaboration, communication, and critical thinking, along with skills traditionally unrelated to computing, such as art, and multimedia.

To initiate the integration of chatbots in learning in the context of this group of students in future offerings, it is anticipated that opportunities to utilise chatbots in a safe environment should be created. This may be accomplished by creating assignments where the scripts compiled as solutions to the set of problems are not assessed, but rather the process each student followed to obtain an answer, as well as each student's reflection on the learning that took place. A short test assessing the knowledge students gained may contribute towards informing the lecturer of learning that occurred, as well as impress on each student how successful the process (s)he followed was in gaining understanding. At the start of such a session, the rules of the session should be spelt out – in terms of the tools students may use, how they should reference such tools, as well as what they can expect regarding learning that is taking place. At the end of such a session, a collective reflection may contribute to students' internalisation of the effects of reliance on chatbots instead of struggling on their own, and how a balance may be achieved.

7. Conclusions

While ChatGPT's capability in text generation is widely recognised, its potential as a code generator, due to its access to GitHub libraries and extensive coding knowledge, has been less explored. The study investigated the extent to which the students-as-participants utilised the free version of ChatGPT for generating code solutions, its implications for plagiarism, and its role in enhancing programming skills. The research journey included various steps, from obtaining ChatGPT-generated scripts to comparing them with student submissions and utilising plagiarism detection tools like Moss.

Surprisingly, the findings indicated that occurrences of direct code plagiarism from ChatGPT were low. While other forms of plagiarism were detected within student submissions, the evidence suggested that students might not be extensively reliant on ChatGPT to generate their programming solutions. This conclusion challenges initial

expectations and opens a new avenue for exploring the educational integration of artificial intelligence tools like ChatGPT.

Although the formative assessment exercises are relatively simple, using similarity detection software has succeeded in creating an awareness of source code plagiarism which will serve the students well in their senior years.

As the programming landscape evolves with the rise of generative artificial intelligence, the paper suggests several recommendations for lecturers and institutions. First, there is a potential for leveraging artificial intelligence as an educational assistant to aid in debugging, code improvement, and explanation. Second, educators could design assignments encouraging students to collaborate with artificial intelligence tools for iterative improvement, promoting a deeper understanding of coding concepts. Moreover, the study highlights the importance of cultivating not only technical skills but also soft skills among future programmers. Collaboration, communication, critical thinking, and ethical considerations will play a pivotal role in the artificial intelligence-driven coding landscape.

The paper also underscores the need to remain adaptable to the changing nature of coding and incorporate coding skills across various disciplines. In essence, this paper initiates a discourse on the evolving relationship between artificial intelligence tools like ChatGPT and human programmers. While the study's outcomes may challenge some assumptions, it also paves the way for innovative pedagogical approaches and considerations in preparing students for a programming landscape increasingly influenced by artificial intelligence and generative technologies. As the field of artificial intelligence continues to advance, lecturers must remain forward-looking, adaptable, and open to harnessing the potential of artificial intelligence tools for enhancing learning and programming skills.

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Exploring Student Expectations of Learning Analytics in South African Higher Education

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Abstract. In the dynamic landscape of higher education, technology plays a pivotal role, with learning analytics (LA) emerging as a significant innovation. However, its adoption and impact in South African higher education remain understudied. This paper investigates student perceptions of LA adoption and its potential in South African higher education. The study surveyed 1219 students from three South African universities to gauge their perceptions of LA adoption. Results indicate a substantial interest among students in utilising LA to enhance their learning experiences, particularly in personalised feedback provision, adaptive teaching methods, and evidence-based decision-making. Despite its growing popularity globally, LA adoption in South African institutions remains in its early stages, with most analytics conducted at the faculty level or higher. The study employs crosstabulation analyses to reveal significant associations between students' awareness of data collection practices and their perceptions of learning effectiveness, quality, and productivity. These findings underscore the importance of transparent communication regarding data practices in educational institutions to foster informed student engagement that leads to the adoption of learning analytics. Enhancing student awareness of data practices is crucial for the successful adoption of LA in South African higher education. Educational institutions must prioritise transparent communication, education, and addressing concerns to create a supportive environment conducive to effective LA utilisation. Ultimately, this can lead to improved learning experiences and productivity among students.

Keywords: Learning Analytics, Student Awareness, Higher Education, Student Perceptions.

1. Introduction

Institutions of Higher Education like any organizations or businesses have been predominately driven by the introduction of technology. Information systems innovation plays a very substantial role in influencing and shaping the success of Higher Education. A significant breakthrough in technology-enhanced learning has happened in the recent decade, with a focus on learning analytics. Data on higher education trends in South Africa indicate that 50% of students enrolled in higher education institutions (HEIs) drop out in their first three years with about 30% dropping out in the first year. Institutions of Higher Education are constantly under pressure to

enhance their rate of success and must undergo difficult and time-consuming periodic accreditation evaluations, which are essential for attracting students and improving their financial standing. The purpose of this study is to investigate students' perceptions of the adoption of learning analytics and their interest in using learning analytics in education.

While learning analytics has been identified as a field attempting to address systemic equality and quality challenges within institutions of higher education across and within regions, its acceptance has been primarily in the Global North to date. Learning analytics has received minimal attention in the global south, including South African institutions of higher education. This could be due to a variety of factors such as socioeconomic level, leadership commitment, higher education funding, and political status.

Therefore, the study surveyed 1219 students from three institutions of higher education in South Africa to investigate their perceptions of the adoption of learning analytics in their education. Through the results, students are searching for increased learning outcomes, quality of learning activities with the same effort and increased learning effectiveness. According to the findings, there is considerable interest in adopting learning analytics to improve their learning experience, particularly in providing individualized feedback, adapting teaching approaches to students' requirements, and making evidence-based educational decisions. The study identified prospects for adopting learning analytics in South African institutions of higher education based on the examination of the student's views.

2. Challenges of Higher Education in South Africa

Many South African institutes of higher learning are in the post-merger phase. This changing landscape has brought a lot of issues, resulting in large waves of uncertainties. At the same time, the introduction of the Internet and the use of information technology (IT) in tertiary institutions has resulted in an exponential increase in rivalry for clients, requiring these institutions to struggle for distinctiveness and internationalisation [2]. This has encouraged South African higher education institutions to begin to make sense of the data collected through their e-learning systems. Online learning is changing the face of teaching and learning, with educators and students introducing new instructional approaches and utilising new communication channels such as discussion boards and chat rooms [3].

According to researchers [4] [5] South Africa has advanced digital infrastructure and is considered one of the most developed countries in Africa. Despite being one of the most unequal societies, the country aims to become a hub of academic achievement on the continent [6]. One of the challenges that are faced in South Africa is that broadband connectivity is limited due to high costs and ageing infrastructure [7]. Some parts of the country of South Africa do not have access to the Internet and computers. According to research conducted by the United Nations Broadband Commission (2020) [1], the number of Africans who use the Internet has climbed from 81 million in 2010 to 294 million in 2019, out of a total population of roughly 1.3 billion, accounting for approximately 21% of the population. It is also possible to investigate the relationship between the comparatively low levels of digitisation of higher education on the African continent, the usage of LMSs, and the resultant possibility for LA [8].

Learning management systems (LMS) were introduced by higher education institutions in order to improve teaching and learning. LMS are at the front position of the online technologies used in HE, making sombre impression on patterns of learning and teaching [9]. Although LMSs have been used for more than a decade now, they are still in the forefront for learners' information collection and storage. In a limited space of time, they have become the most adopted and used educational information system in HE, following the Internet and office applications [10].

Data-driven decision-making in higher education enhances student retention, provides transparency in financial reporting, improves space, safety, and security management, visualizes operations in real time, and provides fact-based decision support [11]. When higher education institutions use data to manage important performance indicators, they save money, reduce the time between enrollment and graduation, and have more transparent ways to analyse successes and improve projections [12, 13]. Despite the potential benefits of analytical tools, academic administrators have yet to adopt them. The study intends to uncover the challenges behind why academic administrators in institutions of higher education haven't utilized analytics to boost efficiencies.

This study will take a South African perspective focus by exploring the students' expectations in the adoption of learning analytics at Higher Education Institutions by investigating institutions that deliver teaching and learning through different mediums namely distance learning, blended learning as well as purely online learning.

3. Learning Analytics Adoption

Learning analytics have gained popularity in recent years, including South African institutions of higher education. For this research, the study adopts the highly cited definition of learning analytics by Siemens [14] namely: "the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimising learning and the environments in which it occurs". Previous extensive studies aimed at understanding why one organisation is more likely than another to adopt an innovation have fuelled innovation adoption [15]. Many organisations have conducted empirical research to identify the characteristics that influence inter-organisational innovation adoption. However, the research has not offered a compelling explanation, and the variability in research outcomes could be attributable to a range of conceptual and methodological issues [16].

For example, some research studies will group organisations of various types into a single category, resulting in conflicting research conclusions. Other studies, however, use alternative metrics and approaches [16]. According to a survey of the state of learning analytics, higher education institutions are very interested, although adoption is still in its early stages. In the context of US higher education, learning analytics has been utilised to minimise barriers to retention and student achievement, as well as to build tailored learning environments [17]. However, there is a higher focus in monitoring or assessing student progress than on predicting learning success or recommending intervention measures [18]. Furthermore, learning analytics is still a curiosity rather than a top priority at most universities [19].

A similar tendency was noticed in Australia's higher education system. According to a study undertaken by Colvin and others, just two of the 32 institutions under

consideration reached the advantage stage, which includes evidence of the execution of several interventions or initiatives supported by data [20]. The remaining cases were either in the preparation stage of learning analytics, the early stage of learning analytics, or the early stage of deployment.

Lemmens and Hanns [21] conducted a comparable study in eight South African institutes of higher learning. Learning analytics are still in the early stages of implementation in South African higher education institutions. The results show that none of the schools reported students being able to perform analytics with their own data, and just one institution reported lecturers performing analytics with their students and/or course data. Overall, most institutions perform analytics at the faculty level or higher [21]. South African institutions lack a uniform framework for internal review of analytical systems, as well as scientific comparison or replication across institutions.

4. Methodology

This research was conducted in three South African Universities. The data collection used purposive sampling. University A was purposefully selected due to its large student population and online and blended courses. University B was chosen because of being one of the new universities in South Africa. University C was chosen based on its blended learning strategies and being situated in remote areas. These universities had a majority of their students studying some of their courses in a blended and/or online mode. The LMS is adopted across different disciplines at these universities. Invitation to participate in this study was sent through university/faculty coordinators. It was considered important to include data at different levels and different disciplines, therefore, the participants in this study were from undergraduate and post-graduate levels. The datasets set covered 1219. Once the dataset was collected, data was prepared for analysis.

4.1. Data Collection

The research study employed a questionnaire as the quantitative data collection instrument, featuring both closed-ended questions and closed-ended questions. The rationale behind selecting a questionnaire as the research instrument stems from its versatility. Questionnaires are cost-effective, easy to administer across varying population sizes, and facilitate the collection of large quantitative datasets [22]. Although for the purpose of the study, employing a questionnaire was straightforward and swift as it was done online, meticulous attention was taken to ensure the accuracy and appropriateness of the wording, layout, and sequence of the questions to yield valid outcomes [23]. Given the constraints of time and cost in this research study, employing an online questionnaire facilitated effective and efficient time management by eliminating the need for travel to the participant's location. The data was collected for over a period of two years.

An email was sent to participants, and it explicitly described the study and its objectives and the approximate duration of the survey. The Likert scale questions were designed to gauge students' awareness of data collection practices by their university. They measure the level of awareness on a scale from complete knowledge to lack of awareness, including the ability to find out more information if needed.

Table 1. Measuring the level of awareness

Do you know what data is collected about you and your activities by your university?
Yes – I am fully aware of all data that my university collects about me.
I am somewhat aware of the data my university collects about me
I am not aware that my university collects data about me
I am not fully aware but I know how to find out

4.2. Research Setting

This study was conducted online in South African institutions of higher education. In the context of this research, the target group comprised of learners registered in institutions of higher education across level of study and across all disciplines. The study did not focus on different fields of study. Participants that were included were from their first-year level of study through PhD level of study.

5. Results

The crosstabulation analysis in Table 2 shows the correlation between respondents' awareness of university data collection and their perspectives on enhancing learning effectiveness. Both the Pearson Chi-Square (212.829) and the Likelihood Ratio (111.569) tests exhibit highly significant p-values of less than $0.001 < 0.05$, indicating a robust association between the two variables.

Table 2. Crosstabulation Analysis measuring awareness of university data collection and effectiveness of learning

Do you know what data is collected about you and your activities by your institutions?						
		I am not aware that my university collects data about me	am not fully aware, but I know how to find out	I am somewhat aware of the data my university collects about me	Yes - I am fully aware of all data that my university collects about me	Total
I will increase my effectiveness on learning	Agree	110	14	216	264	624
	Disagree	0	0	3	2	5
	More or less agree	30	3	47	19	102
	More or Less Disagree	0	0	2	0	2
	Strongly Agree	70	8	116	237	44
	Strongly Disagree	2	0	0	0	2
	Undecided	4	1	14	9	29
Total		217	26	399	535	1219

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	212.829 ^a	28	<,001
Likelihood Ratio	111.569	28	<,001
N of Valid Cases	1219		

The crosstabulation analysis shows the correlation between respondents' awareness of university data collection and their perspectives on enhancing learning effectiveness. Both the Pearson Chi-Square (212.829) and the Likelihood Ratio (111.569) tests exhibit highly significant p-values of less than 0.001 < 0.05, indicating a robust association between the two variables. A closer examination of the data reveals that individuals with full awareness of university data collection are notably more inclined to strongly agree (440 cases) on the proposition of improving learning effectiveness, in contrast to those with lesser awareness. This significant relationship implies that awareness of data collection practices may exert a noticeable influence on educational attitudes.

Table 3. Crosstabulation Analysis measuring awareness of university data collection and increase of quality of learning

		Do you know what data is collected about you and your activities by your institutions?				
		I am not aware that my university collects data about me	I am not fully aware, but I know how to find out	I am somewhat aware of the data my university collects about me	Yes - I am fully aware of all data that my university collects about me	Total
I will increase the quality of learning	Agree	98	15	221	261	610
	Disagree	1	0	2	1	4
	More or less agree	33	4	52	29	126
	More or Less Disagree	0	0	2	2	4
	Strongly Agree	70	6	103	218	406
	Strongly Disagree	2	0	0	0	2
	Undecided	8	1	16	10	35
Total		217	26	399	535	1219

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	142.783 ^a	28	<,001
Likelihood Ratio	101.642	28	<,001
N of Valid Cases	1219		

The crosstabulation analysis reveals a significant association between respondents' awareness of university data collection practices and their commitment to improving learning output. A Pearson Chi-Square test ($\chi^2 = 142.783$, $df = 28$, $p < 0.001$) and a Likelihood Ratio test ($\chi^2 = 101.642$, $df = 28$, $p < 0.001$) indicate a strong relationship. The findings suggest a potential link between awareness of data collection and attitudes towards improving learning outcomes. The results underscore the importance of considering students' awareness of data privacy issues in educational settings to foster a more informed and engaged student body.

Table 4. Crosstabulation Analysis measuring awareness of university data collection and increase in quantity of output

		Do you know what data is collected about you and your activities by your institutions?			
		I am not aware that my university collects data about me	I am not fully aware, but I know how to find out	I am somewhat aware of the data my university collects about me	Yes - I am fully aware of all data that my university collects about me
I will increase the quantity of the output with the same amount of effort	Agree	88	14	212	258
	Disagree	2	0	8	3
	More or less agree	36	5	64	50
	More or Less Disagree	1	0	3	3
	Strongly Agree	70	5	91	204
	Strongly Disagree	3	0	1	0
	Undecided	13	2	18	7
Total		217	26	399	353

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	224.879 ^a	28	<,001
Likelihood Ratio	129.810	28	<,001
N of Valid Cases	1219		

The crosstabulation analysis demonstrates a statistically significant relationship between respondents' awareness of university data collection practices and their inclination to increase the quantity of output with the same amount of effort (Q5). Both the Pearson Chi-Square test ($\chi^2 = 224.879$, $df = 28$, $p < 0.001$) and the Likelihood Ratio test ($\chi^2 = 129.810$, $df = 28$, $p < 0.001$) reveal a strong association. The findings emphasise a dependent connection between respondents' awareness of data collection and their commitment to achieving higher output efficiency. These results suggest that students' awareness of university data practices may influence their willingness to enhance productivity, highlighting the importance of addressing data awareness as a potential factor in shaping student attitudes and behaviours. Further research is warranted to delve into the underlying dynamics of this relationship for informed policy and educational interventions.

6. Discussion

The respondents were categorised based on their awareness levels, ranging from being unaware to fully aware of the data collected. The majority of participants (624) strongly agreed that being fully aware of the data collected by their university would increase their effectiveness in learning and this will result in the adoption of learning analytics, while a smaller number disagreed (5) or expressed more neutral sentiments (102). The chi-square tests, including Pearson Chi-Square and Likelihood Ratio, revealed a highly significant association between awareness levels and the reported impact on learning effectiveness ($p < 0.001$). These results suggest a clear relationship between the level of awareness regarding data collection and individuals' perceptions of its influence on the adoption of learning analytics. The findings emphasize the importance of transparency and communication regarding data practices within educational institutions, potentially influencing policies and communication strategies to enhance students' understanding and comfort with data collection processes.

A notable proportion (610) expressed agreement that being fully aware of the data collected by their university would increase the quality of their learning. Conversely, a smaller number disagreed (4) or expressed more neutral sentiments (126). The chi-square tests, including Pearson Chi-Square and Likelihood Ratio, revealed a highly significant association between awareness levels and the reported impact on the quality of learning ($p < 0.001$). These results indicate a clear relationship between the level of awareness regarding data collection and individuals' perceptions of its influence on the learning experience. The findings underscore the importance of transparency and communication regarding data practices within educational institutions, emphasizing the need for institutions to address awareness gaps and enhance communication strategies regarding data collection processes.

These results indicate a clear relationship between the level of awareness regarding data collection and individuals' perceptions of its influence on productivity. The findings underscore the importance of transparency and communication regarding data practices within educational institutions, emphasising the need for institutions to address awareness gaps and enhance communication strategies related to data collection processes to potentially improve productivity.

7. Limitations

Despite giving significant insights, the study has numerous limitations that should be considered. The dependence on self-reported replies raises the possibility of self-report bias, as individuals may give socially desired answers or incorrectly recall their awareness levels. The cross-sectional design limits our capacity to determine causation or track dynamic changes over time. The sample may not be completely representative of the whole student population, limiting the generalizability of the findings.

8. Conclusions

Ultimately, the study found a significant link between students' awareness of data collected by their university institutions and their judgments of the adoption of learning analytics. The findings show that people who are fully aware of the data collected are more likely to claim an increase in the adoption of learning analytics. This emphasises the significance of open communication and education concerning data practices in educational settings. As universities aim to increase the usage of learning analytics, the findings imply that raising student understanding is a critical aspect. A well-informed student body is more likely to support and engage with learning analytics projects. As a result, educational institutions should emphasise methods for raising awareness, providing clear information about the aim and benefits of learning analytics, and addressing any concerns about data gathering. By doing so, schools can create a supportive climate that encourages students to adopt and effectively use learning analytics tools, thereby improving their learning experiences and productivity.

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Implications of Incorporating Design Thinking in Information Systems Courses

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Abstract. The concept of design thinking has evolved significantly over the years. Originally rooted within other disciplines such as engineering and architecture, it has expanded to education. This research aims to explore the implications of incorporating design thinking in education, particularly in Information Systems courses. Given the increase in demand and popularity of IS careers, it would be imperative to research how design thinking is applied in IS courses that drive IS careers. There is limited literature available in this research area, where, as a consequence, the study aims to address this research gap by potentially adding on to existing literature and knowledge in this field. This research study was a qualitative exploratory case study, which unpacked the perceptions and experiences of educators and students who use design thinking in IS courses. To conceptualise this study, research into the IS2020 curriculum, which lists the competencies or skills required in IS graduates was conducted. A comparison has been made to align the design thinking implications available in the literature with the requisite Information Systems skills that employers look for in Information Systems graduates. Interviews and documentation analysis were done as part of data collection to determine the experiences and perceptions of educators and students who use design thinking. These findings uncovered the different benefits of incorporating design thinking in IS courses, which include skills like critical thinking, creativity, communication skills, collaboration skills, and so forth. Additionally, listening skills were discovered as a new benefit, supplementing existing literature.

Keywords: Information Systems courses, design thinking, IS competencies, IS2020 curriculum, collaboration, critical thinking, creativity.

1. Introduction

Design thinking can be characterised as a methodological approach that is used to understand a user's needs by using problem-solving techniques to clearly identify these needs [15]. It has been implemented in various disciplines like healthcare, business, engineering, and information systems. The educational sector has increasingly adopted design thinking, due to its benefits [24], which include promoting critical thinking, problem-solving, and collaboration skills [16]. Universities are now integrating design thinking into courses such as Design, Engineering, and Information Systems (IS) courses [23]. This study thus focused on one particular discipline, that is, IS courses.

IS courses play a pivotal role in preparing and equipping students with professional skills that enable them to succeed in today's rapidly evolving global landscape, a landscape that is heavily driven by technological advancements [24]. As traditional

methods of teaching and learning gradually become outdated [24], it has become imperative to ensure that IS graduates possess the necessary blend of skills and practical experience sought after by companies. This evolving global landscape has given rise to a pressing need to equip students with industry-relevant expertise and the ability to adapt to changes [24].

In order to solve this need, as well as to identify the industry-level skills that are required by companies, IS courses follow the structured Information Systems (IS2020) curriculum. The IS2020 curriculum plays a crucial role in aligning IS courses with the ever-evolving industry requirements and preparing students for successful careers within the broader information systems field [9]. It provides a comprehensive framework by outlining the essential IS competency skills, abilities and experiences required for students learning information systems. Among these essential skills are critical thinking, creativity, collaboration, and teamwork [20]. By incorporating these skills, IS2020 not only equips students with the theoretical knowledge but also the practical skills necessary to navigate and excel in a rapidly changing technological landscape.

Considering the background discussed, this study explored the implications of incorporating design thinking into Information Systems courses. As employers are constantly seeking good problem-solvers [4] and the demand increases [3], it is essential to research how design thinking can potentially contribute when incorporated in IS courses. Despite the increasing interest in design thinking in education over the past few decades, there is a notable scarcity of comprehensive research examining the implications of incorporating design thinking in IS courses [15]. Further research was vital so as to bridge this gap in literature. In order to solve this research problem and provide a comprehensive and insightful analysis of the research area, the study used an exploratory research approach, an approach typically used to conduct research in order to clarify any misunderstandings or to extensively research an area that is under researched [19]. The study was guided by the research question “How is design thinking used in information systems education?”

1.1. Research Objectives

The primary research objective is “to understand how design thinking is applied in IS education.” To further unpack the main objective, subobjectives were used to provide a more focused direction and generate insightful findings. The sub-objectives were to examine the current state of design thinking in Information Systems courses and to understand student and educator’s perceptions and experiences when using design thinking in IS courses. These research objectives were crucial as a guide in uncovering the different ways in which design thinking is used as well as the implications, filling gaps in literature as identified above. Additionally, the research objectives shed light on aspects of design thinking that lack clarity within existing literature thus contributing to a deeper understanding of design thinking in IS courses.

As a baseline of this study, the paper will explore the use and implications of design thinking in IS courses as found in literature. The study will discuss the characteristics of IS courses, which includes the IS competencies. These IS competencies will be compared to the implications that design thinking has on its users. By doing this comparison, the study seeks insight into the implications by looking at the potential impacts that design thinking has on both IS careers and the skills it requires.

Additionally, the study will also discuss the findings from data collected through interviews and document analysis. It concludes by making several recommendations on possible future research.

2. Literature Review

2.1. Design Thinking as a Pedagogy

Design thinking can be considered a pedagogy or teaching and learning approach. It involves immersing students in environments that encourage them to think and work like expert designers [18]. Students work in multidisciplinary teams by following a structured and iterative design thinking framework [14]. Working in multidisciplinary teams encourages a good growth mindset, creative thinking, and empathetic understanding. This in turn cultivates adaptable, critical thinkers, who are equipped to navigate the complexities of the modern world [17].

Students use design thinking as a technique to solve wicked problems. Wicked problems are problems that are difficult to define and solve [14]. Applying design thinking helps students understand user's needs and generate innovative solutions for challenging problems including products, services and systems. Design thinking is also taught as a mindset to foster human-centred problem-solving that challenges assumptions and encourages analytical and intuitive thinking [17]. In education, design thinking is perceived as a “pedagogical framework that uses empathy as a form of learning” [26]. As a process, it follows five stages (See Fig. 1), which are: empathize, define, ideate, prototype, and test [14]. By integrating both the mindset and process, students gain a deeper understanding of complex problems and can devise innovative solutions.

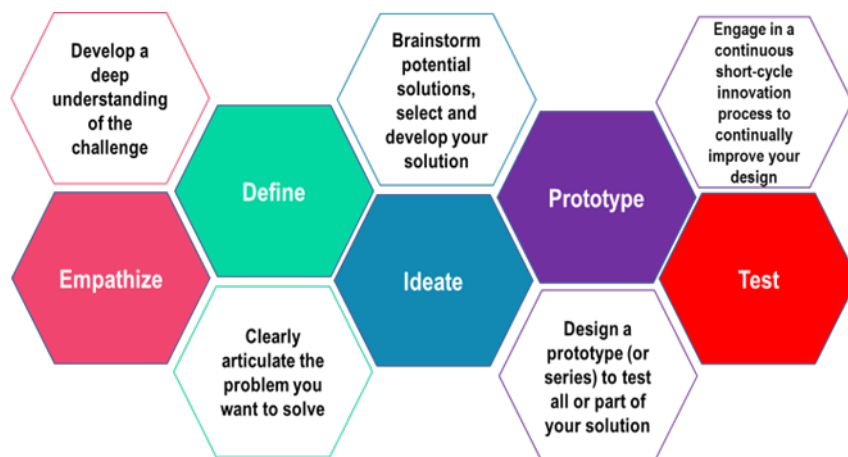


Fig. 1. 5 Stages of design thinking [11].

Incorporation of Design Thinking in IS Courses. In order to effectively practice design thinking in IS education, design thinking follows three pillars, or 3Ps, which are process, place and people.

Process. Design thinking follows a step-by-step approach. This is the five-step process which iteratively occurs over empathising, defining, ideating, prototyping, and testing. Students use this process to solve problems and generate innovative solutions [11]. However, design thinking is also non-linear meaning that in practice, the stages do not always follow a strict sequential path. Students often revisit previous design thinking stages multiple times as they refine their understanding and solutions within a given project [6].

People. In IS courses, a team or group of students are given a project or assignment that requires them to apply a design thinking approach. They work collaboratively throughout the whole project, and they apply design thinking iteratively [22].

Place. To fully support and enhance creative teamwork, design thinking locations are specially and carefully designed [11]. It is proven that the environment in which design thinking occurs further enhances creativity and innovation. Typically, furniture is easily movable and placed on wheels. Other materials are readily available like post-its and crafty items to create prototypes [22]. Students undertake graphical visualisation by drawing and sketching. This reduces cognitive workload thus fostering creativity and advanced problem-solving [8].

2.2. Implications of Design Thinking on Information Systems Education

Design thinking enhances creativity and innovation [12]. Its empathetic approach makes it simpler for students or design thinkers to be innovative. As students engage in the iterative design thinking process, they sharpen their problem-solving skills and become better problem-solvers. This improves their metacognitive skills, which can bring about long-term benefits for their future careers, especially after university [5]. Design thinking not only fosters all the mentioned skills but prepares students for careers in IS by teaching a human-centred approach to technological artefact design [21].

Design thinking fosters engagement and a strong passion for work. By working on a project collaboratively in teams, students naturally find themselves more passionate and engaged with their peers which stimulates active participation [5]. Furthermore, when students prioritise empathy and user-centricity in their projects collaboratively, it creates an environment where ideas are shared, refined, and executed collectively. This collaborative spirit not only enriches the learning experience, but also prepares students for the collaborative dynamics they are likely to encounter in their future careers. More so, the environment they work in induces a mood of engagement and experimentation [22].

Another advantage that design thinking presents is encouraging ideation and experimentation through the use of its unique environment. A design thinking environment and approach encourages students to share their experiences and imagination without judgement thus opening up more ideas and opportunities for discussion as well as collaboration [5]. Aside from the psychological aspect, the physical environment itself in which design thinking students learn in creates a space that encourages productivity and ideation.

The empathising stage of design thinking has proven to enhance students' critical thinking. As students gather feedback from the user and write on post-its or stories, they then discuss the feedback received. This way of sharing ideas and critiquing shared ideas encourages the use of critical thinking skills [13]. Moreover, the diversity of ideas

shared opens up their minds, and challenges students to approach problems from various angles.

2.3. Challenges of Design Thinking

Despite the numerous benefits discussed that design thinking presents, it is important to acknowledge the challenges of design thinking. Design thinking is a new method of learning that students are not accustomed to [12]. It requires a significant shift in mindset from the traditional way of learning. This transition can be difficult for students who are used to educators providing solutions or answers [16]. In contrast, design thinking encourages them to think for themselves while engaging with peers thus fostering critical thinking and creativity. This shift can be challenging as students may be reluctant to embrace change limiting the open-mindedness and creativity that design thinking aims to cultivate.

The iterative and non-linear nature of design thinking can create a sense of confusion and frustration among students [12]. Unlike traditional linear learning methods, design thinking involves moving back and forth between different phases. This can be disorienting for students who are used to a more traditional, structured and linear approach. The ambiguity in design thinking requires students to adapt over time, but initially, it can lead to confusion and anxiety about which phase they are in and what steps to take next [12].

Another challenge with design thinking is the potential for conflict within teams [14]. Working in multidisciplinary teams is a core component of design thinking, however, some students may find it difficult to collaborate with their peers [16]. This can result in their reluctance to openly share ideas resulting in them following the team's decisions without contributing anything meaningful. Additionally, other team members' opinions can impact their own perspectives which may affect the outcome of the design thinking exercise. Disagreements and miscommunication are also common in such settings, further impacting the collaborative process [14].

2.4. IS Competencies

IS courses follow a predetermined curriculum which sets out the relevant skills and competencies that graduates should possess. The recently updated information systems curriculum (IS2020) exposes the need for information systems education to adjust to the ever-changing landscapes [9]. The curriculum lists competency skills, which include critical thinking, creativity, collaboration and teamwork, ethical analysis, intercultural competency, leadership, mathematical and statistical competencies, negotiation, oral communication, problem-solving, and written communication [9]. Some of these skills like critical thinking, creativity, and collaboration overlap with the implications of design thinking.

While all these skills are important, the curriculum highlights three skills that are pivotal when faced with technological advancement. The three critical skills include critical thinking and problem solving; high tolerance for ambiguity and lifelong learning and development [9]. Some of these skills form part of the benefits that design thinking presents. Adopting design thinking as a pedagogical approach suggests that students may acquire the necessary skills and competencies that align with the industry requirements outlined in the IS2020 curriculum.

The IS2020 curriculum plays an important role in ensuring students are equipped with industry level skills. Additionally, it promotes the integration of industry-relevant practices within IS courses. These practices include interdisciplinary perspectives, ethical considerations, and critical thinking skills [9]. By integrating all the aforementioned aspects into the curriculum, the IS2020 curriculum not only addresses the industry’s skill demands but also prepares students to navigate the various challenges typically faced in the workplace.

3. Research Methods

This exploratory research study followed an interpretive and inductive approach with a cross-sectional timeframe. Understanding the subjective experiences of students and educators was crucial to this study. An interpretive research philosophy prioritizes understanding individual perceptions and interpretations [7], making the philosophy ideal for exploring how educators and students perceive using design thinking.

3.1. Data Collection and Analysis

The research was a qualitative case study. The case study was a single institution, a university that has students who are enrolled in IS courses that have design thinking incorporated in them. The university has educators who manage or teach these courses. As this research is exploratory, conducting a case study using this institution allowed an in-depth analysis within a given context which is the university [25].

The methods of data collection that were used in this research are interviews and documentation analysis. The target audience for this research were students enrolled in two third-year exit-level information systems courses, as well as tutors and lecturers teaching information systems and design thinking itself. The two courses, one focused on system development and project management (Course A) and another on project management (Course B) were selected because they were identified to have a specific module (or section) that covers design thinking. The interviews were semi-structured with open-ended questions encouraging participants to voice their experiences freely and unedited. The documentation analysed included past class exercises and tutorials, all of which involved the application of design thinking or questions in the context of IS.

Following participant recruitment, 10 participants volunteered for the research and were interviewed. Of the 10 participants, seven were students, and three were educators who added an extra layer of expertise in the group. Among the three educators, two were lecturers, and one was a design thinking coach. Of the seven students, four were regular students and three were both tutors and students (See Fig. 2).



Fig. 2. A demographic mapping of the participants

Documents obtained for this study included design thinking quizzes done in IS courses and design thinking tutorials completed by students. The design thinking quiz used in this study had five questions and was completed by 113 students. The quiz served as a reflection exercise following the completion of the two IS courses (referred to as Course A and Course B below). Both courses integrated design thinking principles. These documents were very resourceful to the study as a supplement to the interviews. They provided more information on the experiences and perceptions of students who previously participated in design thinking workshops.

As this study followed an inductive approach which involves deriving meaning from collected data and developing theories, themes and conclusions [1], the study used a thematic analysis. This method was well-suited for this research as it enabled the identification of recurring perceptions and experiences of design-thinking users. By examining common themes and patterns, the research concluded the implications of integrating design thinking in IS courses. The findings section presents these themes with participant quotes reflecting the qualitative exploratory nature of the research.

4. Findings

This section reports on the findings generated from interviews, and documentation analysis. The findings have been categorised into themes resulting from conducting a thematic analysis. In order to ensure the objectives of this research study are fulfilled, each theme has been categorised under each corresponding research sub-objective, with further explanation provided. The sub-objectives have been rephrased and listed as follows:

Subobjective 1 - The incorporation of design thinking in IS courses.

Subobjective 2 - Perceptions and experiences of users of design thinking.

4.1. The Incorporation of Design Thinking in IS courses.

This research sub-objective seeks to understand how design thinking is incorporated in IS courses. After conducting a comprehensive analysis of the data gathered from the interviews as well as examining the documentation, three themes emerged which were:

- Design thinking fosters a design-thinking mindset
- Design thinking is taught to develop professional competencies in exit-level courses.
- Design thinking is taught in a conducive environment.

The subheadings will provide further explanation on each of these themes, backed up by quotes from participants.

Design thinking Fosters a Design Thinking Mindset. There was predominant emphasis on the use of design thinking as a mindset. Most students reported to only recall design thinking as a way to understand users' needs. This is done by applying empathy, which is an approach inherent in a design thinking mindset. Below is one of the quiz responses that participants provided. All participants' responses are cited verbatim.

“The key takeaway for me was undoubtedly the importance and criticality that empathy plays in the design thinking process. I was also taught that solutions were only worth investing in if there was a user need for it. This only reinforces the importance of empathy, because empathy is required to understand a user and their needs. Empathy prototyping is, to me, a brand-new way of collecting data and has opened my mind to new ways to approach old business ideas I have had” – Student Quiz #31 – Course B

Although, most students reported not recalling the five-step design thinking process in detail, empathise, define, ideate, prototype and test, they emphasised that they do recall the underlying theory behind it, which is having a design thinking mindset. They understand the importance of design thinking in fostering a user-centric mindset, especially when tackling their IS projects or tutorials.

Professional Competencies and Exit-level Courses. Educators noted that they incorporate design thinking in IS courses to create revolutionary professional skills in students. Incorporating design thinking in IS courses could foster professional skills through the use of real-world problems in design thinking exercises. The institution used in this case study taught design thinking in exit level third and fourth year IS courses. Educators noted that the reason for incorporating design thinking only in exit level courses is because students are about to enter the workforce therefore, they need to be prepared for IS professions, such as systems analyst, or business analyst.

“We are prepping students in a way that's going to change how our workspaces operate and improve on that, so developing professional skills” – Interview Participant #3 - Design Thinking Coach

Furthermore, by following the five-stage design thinking process to empathise, define ideate, prototype and test, it creates a design mindset, which is beneficial when approaching real-world problems. Students are encouraged to brainstorm tons of ideas in the brainstorming stage. They are encouraged to share all ideas and to keep in mind that no ideas are small or silly. All these ways form part of design thinking that educators mentioned to use when preparing students for an IS profession.

“There's no such thing as a silly idea. Generate as many ideas as possible and then test them. Prototyping and testing them in some tangible way is the way to still not prove that your solution works but testing for the purpose of collecting input. Those are some of the mindset and principles embedded in design thinking that I thought would be absolutely critical to our students who aim to become a either a software designer or a systems analyst or business analyst and project managers. These are basically all tasks that involve interacting with people, involving problems that are technical. All these values and principles coming from design thinking would benefit them significantly.” - Interview Participant #5 – Lecturer

A Conducive Environment. Design thinking is taught in specially designed locations. In this case study, the institution made use of their design thinking school, which was specially designed for design thinking learning. Students and educators reported that

the use of the design thinking school fostered a much more conducive environment as compared to lecture theatres/ classrooms.

“What I liked most was the environment. It was a clean and bright environment and I found that I always felt “free” when I was there. I liked how interactive it was and the fact that it was less structured than most of my classes made me feel at ease. And drawing on the tables; that was the best!” – Student Quiz #43 - Course B

Students reported that they enjoyed this method of learning. They liked working together in multidisciplinary teams. They work with students from other faculties or different majors thus promoting sharing of ideas and perspectives. Furthermore, for those who used to like working alone, they learnt to work in groups more, and experienced the best way to do this, which in turn improved their collaboration skills.

“I really enjoyed how interactive the sessions were. It was great to be able to work together actively as a team instead of simply listening to a lecture. It felt easier to learn and focus with this format of teaching.”- Student Quiz #57 – Course A

Students felt it was both a novel and an easier way of learning, as opposed to the traditional way of learning, which involved being in a lecture and taking down notes. It was an interactive and practical way of learning that enhanced their creativity. By writing on tables when brainstorming numerous unlimited ideas, they could exhaust their creativity, thereby making it easier to solve problems.

4.2. Perceptions and Experiences of Users of Design Thinking

The research objectives seek to understand the perceptions and experiences of students and educators who use design thinking in IS courses. Several themes emerged from the data collected, namely:

- the effects of working in a group during design thinking sessions;
- students find learning design thinking engaging and mind-stimulating;
- design thinking that fosters listening skills; and
- design thinking courses are time-constrained.

The Effects of Working in a Group. Students have reported to have gained collaboration skills. Educators have also reflected on the times when they were students and have reported to have gained collaboration skills, which has helped them in their careers after their university studies.

“Having multiple people is very useful in the design process because everyone thinks differently and hearing different perspectives helps to reach/create better or more thorough solutions.” – Student Quiz #70 - Course A

“But if I think about the competencies, the things that I've found powerful in design thinking is probably almost all focused around the collaboration space.” – Interview Participant#3 - Design thinking coach

Engaging and Mind-stimulating. Students enjoy design thinking as a way of learning as opposed to the traditional way. They enjoy this way of learning as well as the environment in which design thinking is taught. They feel like design thinking is very interactive and keeps them engaged throughout.

“I liked how interactive the design thinking sessions were. Not only did we gain insight from our team members, but also from other teams during the interviews. It was both educational and fun, and really made us think outside the box which is an essential skill to have when creating solutions.” – Student Quiz #48 – Course A.

Students and educators have reported on the importance of design thinking in stimulating the mind. They believe it fosters mind stimulation and creativity. Even if you are not naturally creative, some participants reflected on how design thinking brought out their creativity. By challenging them when brainstorming ideas and finding solutions, design thinkers can challenge themselves to think outside the box and be creative with their ideas and/or solutions.

“I never used to consider myself as a creative person... but only after going through the design thinking classes I realised how I can intentionally activate creative choices, participate in an innovative creative exercise, and that that creativity is not for those who are born creative or not.” - Interview Participant #5 – Lecturer

Listening Skills. Students reported to have gained listening skills. By working collaboratively in teams and taking the time to listen to their peers in order to solve the given problem, they believe to have potentially gained listening skills. Listening skills are essential when collecting requirements and trying to understand the user’s needs. Students understand that they should take the time to listen to the user’s needs and interpret their thoughts and ideas by empathising with them. Getting iterative constructive feedback and taking the time to amend solutions according to the user’s feedback and needs is crucial and requires open communication and active listening. Hence, students have noted that they understand the power of actively listening when working individually or with their peers on a project to solve a given problem.

“My key takeaway was that when empathising with a customer, I should forget what I know and just focus on listening to them. Listen more and talk less. It was also interesting how challenging it was to ask questions without being biased towards to any particular kind of answer.” - Student Quiz #62 -Course B

“Learning how to listen attentively and not imposing one's ideas on others helps evolve you a designer because you get to see the world from an entirely different perspective.” – Student Quiz #95 -Course B

Time Constrained. As previously discovered, since design thinking is only introduced to students late in their academic years, that is, in their exit-level courses, students and educators have noted that students do not recall doing design thinking. This is because there was not enough time allocated to it.

“Because of the limited time we had to complete the example, we did not thoroughly cover each concept we had learned and wished we had more time for the design thinking sessions”. – Student Quiz #49 – Course A

“My concern is that students don't have enough exposure so we only have one week and for such an impactful and different way of thinking and looking at things one does whether one week can really create a long-lasting deeper impact”. – Interview Participant #5 – Lecturer

5. Discussion

5.1. Implications of Design Thinking on IS courses

Referencing the findings found in literature, particularly the three Ps, namely People, Place and Process [11], we can unpack how design thinking is designed in IS courses. One of the ways in which design thinking is incorporated in IS courses is through the use of a conducive environment. The “Place” element asserts that design thinking is taught in specially designed locations. These locations play a significant role in fostering the effectiveness of design thinking. These purposefully designed spaces contribute to an environment that is conducive for learning design thinking, with a particular focus on stimulating creativity and teamwork [11]. Students love learning in design thinking locations. They perceive these environments as a different way of learning, one which is unique and engaging. Design thinking environments are interactive and practical, which encourages active participation from students.

Furthermore, as part of the 3Ps, students learn design thinking and work on projects as a team (People). They work collaboratively to solve a given problem, which is essential as students can share their various ideas when tackling a problem [14]. They bring different perspectives, based on their various experiences and backgrounds. As a result, students gain good collaboration skills [14]. Working in groups also prepares students well for collaborative work in the workspace.

Apart from gaining collaboration skills in the course of working collaboratively on projects, students enhance their active listening skills. The interactive nature of engaging with their peers while tackling projects encourages the exchange of different experiences and perceptions. This exchange is valuable and fosters a deeper understanding of different viewpoints, thereby strengthening the bonds of teamwork. As a result, students emerge from this design thinking learning experience with good listening skills, collaboration, and problem-solving abilities [2]. Overall, these are skills that are essential for their future endeavours post university.

As previously discussed, as part of the 3P's (Process), it is evident that students learn the five-step design thinking process, empathise, define, and ideate, prototype and test in IS courses [11]. However, as per the data collected, most students recall design thinking as a mindset, focusing on empathizing with users to solve problems. This could mean that this pedagogical strategy of teaching design thinking may have created a long-lasting impact on students. It is a concept that they will always remember and could potentially be used as a cognitive tool in the future. Furthermore, by teaching design thinking this way, it fosters mind stimulation and creativity [14]. The iterative

process of empathising with the user and applying a design-thinking mindset encourages students to be creative and think outside the box [15].

Design thinking is taught in exit-level courses using real world problems. Real-world problems mimic potential projects that students may work on after they graduate. Teaching design thinking in exit-level courses, in particular, may prepare and potentially equip students with the necessary experience to tackle projects in a work setting emanating from their fresh knowledge of design thinking. Using real-world problems could further potentially prepare students for a professional environment by fostering professional skills. Such professional skills include communication skills and critical thinking. These skills also align with the IS2020 curriculum, which serves as a guide to requisite IS skills for careers in IS.

Further exploring students' perceptions on design thinking reveals that students find it engaging and much more enjoyable as opposed to the traditional way of learning. The use of different learning tools within the design thinking framework makes it engaging [10]. Students benefit from a wide range of creative resources, including collaborative workshops, visual aids, prototypes, and technology-driven platforms, which enhance and stimulate their interest and engagement [22].

Both students and educators have expressed that design thinking teaching and learning is time-constrained. Since it is applied only in exit-level courses, students do not have enough time to digest and apply the content learned. Learning design thinking for a short period of time may not create a long-lasting memory of the content. As a result, students often find themselves unable to recall their engagement with design thinking, leading to a disconnect between the learning process and its practical application. Furthermore, for those who do recollect their experiences with design thinking, it is typically remembered as an empathy-driven approach, rather than the full five-step process of design thinking. This selective recall further poses limitations imposed by the time constraints in the teaching of design thinking.

5.2. Research Contribution

Fig. 3 shows the implications that design thinking has on IS courses derived from literature as well as added discoveries emanating from the findings of this research.

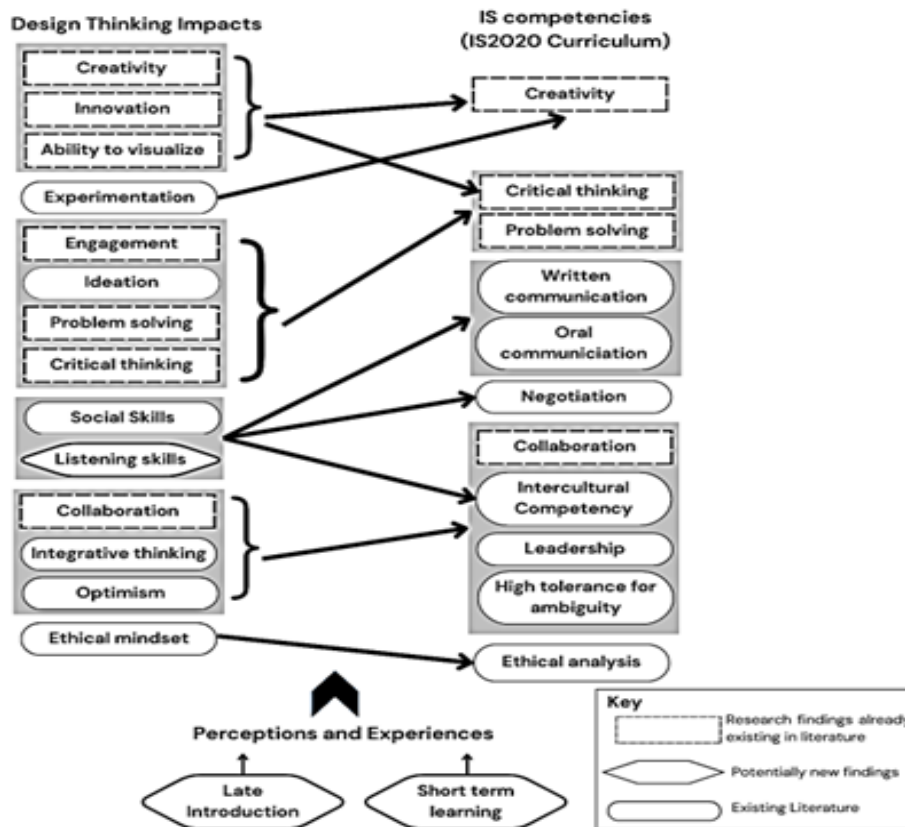


Fig. 3. Implications that design thinking has on IS courses and how they align with the IS2020 Curriculum

The visual representation in Figure 3 serves as a conceptual framework summarising key insights from the literature review on introducing design thinking into IS courses. This framework illustrates that integrating design thinking offers benefits such as enhanced creativity, critical thinking, and collaboration. Design thinking principles motivate students to think innovatively, challenge assumptions, and address problems from diverse perspectives, aligning with the IS competencies outlined in the IS2020 curriculum. The overlap observed in Fig. 3 demonstrates how design thinking complements and reinforces the skills required for IS professionals, contributing to students' development into competent IS professionals. Embracing design thinking as a pedagogical approach aligns students with industry requirements, as outlined in the IS2020 curriculum, thereby enhancing their preparedness and abilities to succeed in the field.

This research discovered that students gain listening skills from using design thinking in their projects. In addition to the skills present in the literature found, listening skills could be a good addition and significant benefit to design thinking. Design thinking, by its very essence, promotes active communication and collaboration, both with end-users as well as among team members. This continuous

and iterative interaction enhances listening skills by understanding user needs, gathering feedback, and considering the different perspectives of team members. As a result, students can find themselves honing their listening skills through listening attentively and empathetically. In turn, this will enhance their professional skills in terms of oral communication, negotiation, and so on.

Perceptions and experiences are potentially influenced by the late introduction of design thinking in IS courses, as well as the short-term nature of the learning period. Because students are only introduced to design thinking in their final year of study this potentially affects their perceptions and experiences due to late introduction and short-term learning, which happens over a period of one week for most IS courses, as shown in the findings. Furthermore, from the findings, this research discovered some of the benefits of design thinking which are creativity, innovation, and the ability to visualise. These are already considered in existing literature, thereby corroborating the potential benefits of design thinking incorporated in IS courses.

6. Conclusions and Future Research

The research unpacked how design thinking is used in Information Systems courses, which was the primary objective. By analysing both the structure of IS courses and design thinking principles, the study uncovered the various implications of incorporating design thinking into IS courses. The firsthand experiences and perceptions collected from design thinking users provided a nuanced and personal perspective on the effects of incorporating design thinking in IS courses. Some of the key implications found in the research include acquiring problem-solving, collaboration, and critical thinking skills.

As more businesses and organisations continually rely on digital technologies to drive business operations, the demand for IS professionals increases. As gathered from this research, in response to this demand, IS courses are constantly striving to find effective ways to equip students with the essential competencies required to thrive in a work environment. Some of these skills outlined in the IS2020 curriculum include creativity, critical thinking, collaboration and problem-solving. The findings from this study show that incorporating design thinking in IS courses contributes to fostering such skills.

The characteristics of design thinking, which include a conducive environment for learning, a user-centric way of teaching and mindset building are all essential characteristics that drive its potential in IS courses. Students find it engaging which could potentially increase retention of learning material and participation. The above characteristics enhance student's listening skills by applying a user centric way of thinking when understanding user's needs. Students take the time to listen to their peers and take into consideration their input. This is beneficial in a work environment where active listening is required, whether through client interaction or project teamwork,

To ensure a long-lasting grasp of the design thinking concepts, it is advisable to introduce design thinking early in student's academic process, particularly in their first-year courses. Incorporating design thinking into entry-level information systems courses can provide students with the opportunity and foundation to be more familiar with the design thinking approach. This early exposure not only helps students develop

a solid foundation in design thinking, but it hones valuable IS skills early and is highly valued by employers.

There are promising prospects for further research in this area. One such avenue could be to further research the extent to which IS graduates who are already working in the information systems space use design thinking. Researching this area could shed light on whether these students have successfully integrated design thinking into their work environment. The research may unpack the extent to which the use of design thinking by these students was impacted by how design thinking was introduced and taught in their IS courses. Furthermore, it would be insightful to determine the specific skills they find the most useful or beneficial, stemming from their exposure to design thinking in IS courses.

Other future research prospects could also include exploring other disciplines or subjects in which design thinking is used and comparing it to its implications when incorporated in IS courses. Such comparative studies could help to examine the implications of design thinking in various educational contexts or subjects, thereby further enriching our understanding of its impact on problem-solving and creativity benefits across different fields.

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The Current State of Information Systems Education in South Africa: A Systematic Literature Review

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Abstract. Over the years there has been a growing interest in information system education research, not only in western countries where the discipline is relatively well-established, but also in the context of developing countries. However, within South Africa, the information systems education discourse remains fragmented. This study addresses this by conducting a systematic literature review of academic literature on information systems education published in South African conferences. The aim is to synthesise the discourse to current areas of focus. The findings highlight the multifaceted nature of information systems education in South Africa, emphasising aspects such as curriculum and workforce readiness, technology-enhanced learning, pedagogical innovation, graduate education, industry engagement, and accessibility and inclusiveness. The findings from this study can be useful to practitioners and researchers in identifying commonalities and even gaps that warrant further exploration both with the classroom as well as in the research more broadly.

Keywords: Information systems education (ISE), South Africa, Curriculum, Pedagogy.

1. Introduction: On the State of Information Systems Education

Information Systems Education (ISE) is a field that teaches technical skills for designing, implementing, and evaluating technology solutions to improve organisational and societal processes [1]. It covers the interaction between technology, data, and people in various organisational settings. The curriculum blends computer science, business, and social sciences, providing practical skills in programming, data analysis, project management, and ethical decision-making [2]. The goal of ISE is to prepare students for careers in IT-related fields such as software development, database administration, systems analysis, project management, and IT consulting [3]. Graduates of information systems programmes possess the expertise to create and maintain advanced IT systems that meet the needs of modern businesses and organisations [4].

Over the years, there have been changes undertaken by ISE due to the increasing demand for skilled individuals in the field of technology [5]. Like many other countries, South Africa's rapid technological leap and industry wide digital shift are fuelling a surge in demand for information systems graduates [6]. The provided data by the National Advisory Council on Innovation (NACI) reveals a certain trend, namely the SMMEs sector within the Higher Education Seed Fund portfolio allocated 47% of its funding to the ICT sector between 2013 and 2020 [7]. This substantial investment emphasises the South African government's recognition of the role IT plays in driving

technological advancements and digital transformation. However, a crucial element is missing, the literature on the state of ISE in South Africa is limited, and this can be attributed to a combination of factors, including resource constraints, the emerging nature of the field, limited collaboration, and a lack of awareness and recognition [1]. These factors have resulted in a scarcity of studies in the region, which poses challenges in understanding the current state of ISE, including essential components of an effective curriculum, teaching approaches, research methodologies, and the obstacles faced by educational institutions in delivering quality education in this field [8, 9].

The main research question for this study is “What is the current state of ISE discourse in South Africa, as reflected in published ISE literature?” The study builds upon the groundwork laid by another study that explored research on ISE in Africa [8]. This study focuses on the state of ISE, specifically in South Africa, through the lens of research work published within the local (South African) conferences. The focus on local conferences plays a useful role of highlighting the work carried out by local researchers who, for one reason or another, prefer to present and publish their valuable work through local conferences instead of established international journals.

The next sessions of the paper will present the background literature on the topic. This will be followed by a brief description of the research methods that guided the data collection for the study. Thereafter, the key findings will be presented followed by a conclusion and recommendations on future research.

2. Background

The background section delves into curriculum, pedagogies, resources and infrastructure, and the representation of underrepresented groups in ISE.

2.1. Curriculum

Information systems curricula worldwide are faced with several common challenges [10]. Rapid technological advancements constantly demand updates to ensure graduates possess relevant skills, while the diversity of information systems applications presents another challenge, as information systems is utilised across a wide range of industries [2, 11]. Another challenge is striking a balance between breadth and depth of knowledge, which is a continuous struggle, moreover, finding instructors proficient in both technical and business skills, proves itself to be a daunting task for higher education institutions [10].

In Africa, information systems curricula are faced with additional hurdles, one such being to ensure curriculum relevance to local contexts [8], where ISE should consider social, economic, and political factors to prepare students for success in their idiosyncratic local job markets [5, 8]. Many universities on the Continent struggle with limited resources, making it challenging to provide students with access to up-to-date technologies and training [12]. Furthermore, there is a shortage of qualified information systems instructors in Africa, partly due to a lack of professional development opportunities for professors [13]. To overcome such challenges and maximise the impact of ISE in Africa, recommendations include investing in resources for technology access, attracting skilled instructors with competitive salaries and development

opportunities, improving internet connectivity, forming partnerships for internships, and customising the curriculum based on local business needs [14, 15].

2.2. Pedagogies

Pedagogy in ISE has changed in recent years, having previously been focused on traditional teaching methods like lectures and exams; however, now things are different [3,11]. While traditional methods like lectures and exams remain prevalent, the evolving field, diverse student needs, and ever-growing technological advancements are driving a wave of innovative pedagogies [18, 19]. These new approaches aim to address concerns about the effectiveness of traditional methods and personalise learning experiences [20]. There are some new and creative ways to teach with problem-based learning immersing students in real-world challenges to hone their problem-solving abilities, while blended learning offers flexibility by combining online and in-person instruction [21, 22]. The flipped classroom model encourages independent learning and interactive activities in class, demanding greater student autonomy [23]. However, each approach comes with its own set of challenges, such as finding suitable problems for problem-based learning, ensuring equitable access to technology for blended learning, and fostering self-discipline in the flipped classroom setting [24–26].

Beyond technology-enhanced methods, collaborative learning builds teamwork and communication skills, while experiential learning bridges the gap between theory and practice, both facing challenges with managing group dynamics and resource limitations, respectively [18, 27, 28]. Gamification, the infusion of game elements into learning, enhances motivation but may not resonate with all students [29]. Simulation-based learning offers a secure environment for practical application but requires substantial investments and may lack real-world complexity [30]. Although these innovative methods grapple with various hurdles, particularly in developing nations, they offer an invaluable contribution to the overall quality of ISE [30]. By bridging skill gaps, boosting student engagement, and promoting deeper understanding, they represent a promising step towards the future of this dynamic field.

2.3. Resources and Infrastructure

Effective ISE hinges on quality resources and infrastructure. Textbooks, software, databases, computer labs, fast internet, and tech tools all play a crucial role in providing hands-on training and practical learning opportunities for students [31]. Unfortunately, limited access and inadequate infrastructure in certain regions hamper students' ability to acquire essential skills and knowledge for success in this field [13]. Therefore, ensuring sufficient resources and infrastructure is paramount for delivering effective ISE.

2.4. Underrepresented Groups in Information Systems Education

Historically, underrepresented groups, including women and individuals from low-income backgrounds, have encountered barriers in accessing opportunities in ISE [32]. Outreach and recruitment endeavours play a pivotal role in enhancing accessibility by creating pathways for underrepresented groups, commencing from early education in

STEM fields [33]. Despite progress, women continue to be underrepresented in ISE, a phenomenon attributed to gender stereotypes, the absence of role models, and limited support in male-dominated environments [32]. Persons with disabilities similarly encounter challenges in ISE, encompassing limited technology access, the need for accommodations, stigma, and discrimination [34]. To champion inclusivity, measures such as fostering a welcoming environment, offering mentorship and support programmes, actively recruiting women, challenging gender stereotypes, and providing assistive technology and accommodations for students with disabilities are indispensable [32,34]. Furthermore, financial support and measures aimed at dismantling bias and stereotypes serve as crucial steps in promoting diversity and inclusivity in ISE [35].

3. Data Collection

This study employed a systematic literature review (SLR) methodology as outlined by [36] and [37]. The Southern African Computer Lecturers' Association and South African Institute of Computer Scientists and Information Technologist conferences were selected for this study's data collection, as the two largest and most prestigious conferences in South Africa for research in IS [38]. The conferences attract a wide range of information systems researchers from academia, industry, and government, and they provide a platform for the dissemination of new research findings, this ensures that the findings of this study are representative of the state of ISE research in South Africa [39].

In addition, the SACLA and SAICSIT conferences place a strong focus on ISE, where many papers presented at these conferences address topics such as curriculum development, teaching methods, student learning outcomes, and the role of IS in society [40]. This focus on ISE makes these conferences a valuable source of information for this study. Table 1 provides a concise summary of our paper selection criteria. Papers that do not meet these criteria are systematically excluded from our analysis to ensure the highest quality and relevance in the study.

Table 5. Inclusion and exclusion criteria

Criteria	Include	Exclude
1. Year	Published in the 2018-2022 SACLA and SAICSIT proceedings	Not published in the 2018-2022 SACLA and SAICSIT Proceedings
2. Paper focus	Discussions and findings gave insights about the state of ISE	Discussions and findings did not give insights about the state of ISE
3. Country	Focused on ISE in South Africa	Not focused on ISE in South Africa
4. Level of education	Focused on higher education	Not focused on higher education

To guarantee accuracy in representing the state of ISE in South Africa, this study implemented a rigorous two-phase screening process, drawing criteria from [36] and [41]. Figure 1 provides a clear overview of the systematic literature review process.

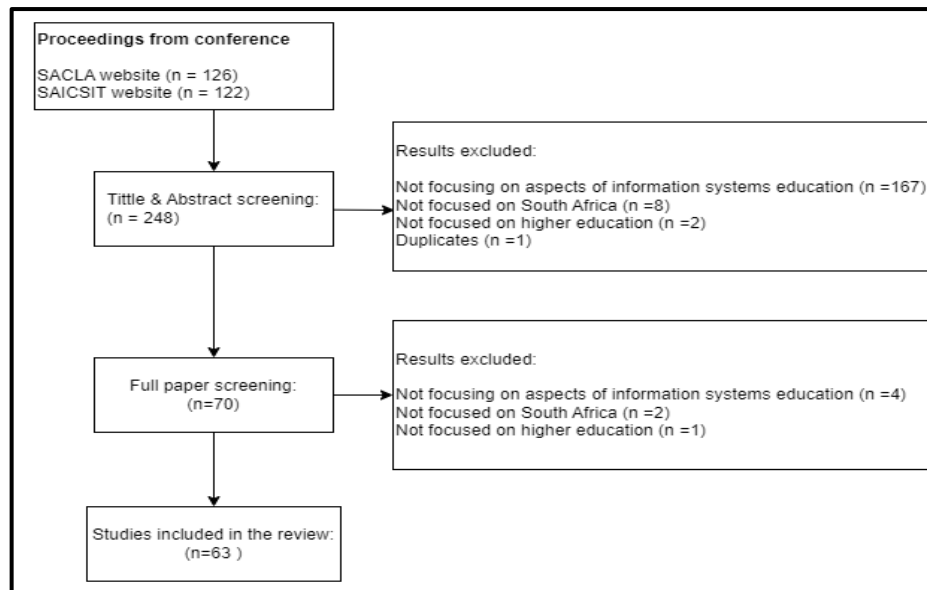


Fig. 1. PRISMA Diagram

The analysis process began with an inductive approach. After the screening process the papers that passed (63 papers) were then input into NVIVO software for a thematic analysis. This involved creating an initial set of 72 codes, which were subsequently refined by eliminating duplicates and merging codes that were similar or closely related. This led to the development of 23 initial themes. These initial themes were further grouped together, resulting in 7 main themes. A visual representation of the data analysis progression can be found in Figure 2 in Appendix A.

4. Results

The key findings are summarised into 7 key themes, namely: pedagogical innovation, curriculum and workforce readiness, technology-enhanced learning, student-centred learning, industry engagement and partnership, accessibility and inclusiveness, and lastly, graduate education in information systems. These themes are discussed in detail below.

4.1. Pedagogical Innovation

The findings from the exploration of pedagogical innovation for South African ISE highlight a range of strategies aimed at enhancing the learning experience. One key aspect of this exploration is the acknowledgement of the flexibility offered by online learning [42]. The implementation of online learning is influenced by the result of the Covid-19 pandemic, which became of benefit to students due to the opportunity for asynchronous access to lecture videos and other learning materials [43, 44]. It is essential to note that some people have concerns about online learning, believing that students sometimes feel that educators are not as actively involved, leading to a sense that they need to take more responsibility for their own learning [45]. Blended learning is emphasised as well, incorporating the crucial dimensions of technology and environmental readiness, which emphasises the importance of institutional preparedness [46]. Blended learning in ISE improves practical problem-solving by combining in-person classes with online learning, enabling students to apply theory in real-world scenarios and resulting in a deeper and more practical grasp of IS concepts [47].

Another approach that has been discussed is gamification. Gamification is identified as a method for fostering teamwork skills, and there is a notable interest among students in further exploring its potential [48]. With gamification, it is possible to enhance engagement and motivation by implementing incentive systems like badges and leader boards for tasks, interactions, and peer support [49]. Furthermore, IS instructors can utilise gamification to build a sense of community and provide immediate feedback, fostering students' intention to continue using information systems learning methods [50]. Additionally, the strategic use of social media is proposed to enhance student-lecturer interaction, and innovative approaches that balance theory with practical application are recognised for their positive impact on student performance and satisfaction [51].

Findings on active learning methods show that collaborative learning helps students in computing courses by enhancing their critical thinking, problem-solving skills, and communication abilities, while encouraging independence [52]. Teaching project management with real-world case studies, simulations, and role-playing has proven effective in equipping students with the skills and attitudes needed for success [53]. Implementing interactive learning with activities like case studies and group projects in systems analysis and design courses has led to increased student engagement and improved learning outcomes [54]. Continuous assessment within constructivist frameworks cultivates research skills by fostering curiosity and questioning, providing opportunities for skill development, and promoting collaborative learning [55, 56]. This collection of insights portrays a dynamic pedagogical landscape in ISE, with the

potential to enhance engagement, learning outcomes, and adaptability to the evolving educational environment.

4.2. Curriculum and Workforce Readiness

The South African Information Technology industry is currently grappling with a skills shortage and a misalignment between the skills offered by the information systems curriculum and the demands of the job market, resulting in consequences for both employers and employees in the industry [57]. Alumni satisfaction with the information systems curriculum appears to be relatively high, with graduates from the School of ICT at the University of Pretoria generally expressing contentment, as evidenced by an average rating of 4.1 out of 5 [58]. Nonetheless, this apparent satisfaction among alumni is counterbalanced by the challenge posed by unprepared graduates in the IT industry. IT graduates often lack the necessary skills demanded by employers, including both soft skills and technical expertise, resulting in costly problems for employers, such as decreased productivity and higher turnover rates [57]. Secondary institute scholars in South Africa mostly lack awareness of career opportunities in the ICT sector, owing to various factors, including insufficient encouragement from parents, teachers, and guidance counsellors [59].

Furthermore, university students are also frequently under-informed about IT career opportunities and paths, highlighting the lack of clarity regarding IT job descriptions and career tracks, despite academic departments being mandated by accreditation bodies to provide career guidance [60]. To bridge the divide between skills taught in higher education institutions and those in demand within the industry, hackathons and project-based learning have emerged as a valuable method for preparing students for the workplace [61, 62]. These methods empower students with proficiencies, including adeptness with emerging technologies, cross-platform development, and the utilisation of resources such as Google APIs and public SMS services [63]

Other aspects pertaining to workforce readiness and IS curricula are as follows: firstly, a portion of students demonstrate a perceived awareness of automation, suggesting that they are acquainted with technological advancements in the information systems field [64]. Furthermore, students are notably motivated to pursue information systems studies due to perceived career prospects and the demand for IS skills [65]. However, a concerning gap exists in the understanding of job titles and descriptions among students, particularly those who speak African languages, emphasising the need for proactive IT career awareness programmes [66]. Lastly, there is a notable discord between what IT students' employers prioritise and what is taught in IS courses, underlining the importance of revising curricula to better match industry needs [67,68]. These common findings collectively underscore the necessity of bridging the gap between theoretical knowledge and practical skills in ISE, as well as enhancing career awareness initiatives to equip graduates with the skills and understanding required for successful entry into the information systems workforce [69].

4.3. Technology-Enhanced Learning

Exploration of the state of ISE in South Africa forms a narrative highlighting the transformative potential of technology in pedagogy [70]. The research showcases a range of innovative approaches, starting with the adoption of binary scales in rubrics to

evaluate project-based assessments, this method promises more granular and dynamic feedback for students, enhancing the learning process [71]. Virtual Reality (VR) emerges as a powerful tool with numerous advantages, such as promoting active learning, breaking language barriers, and offering flexible learning options [72]. Robotics, while presenting challenges in funding and group dynamics, they provide valuable hands-on experiences [73]. Additionally, the integration of technology, such as mobile devices, has prompted a paradigm shift in content delivery and accentuates the need for universities to adapt their practices [74].

Educational technologies (ETs) positively influence subject content learning and essential lifelong skills, they enhance critical thinking and problem-solving through interactive activities, encourage effective communication and teamwork, foster digital literacy, and promote self-directed learning and metacognition [75]. Tablets are also recognised as a beneficial tool, since they enhance collaboration and skill development through real-time student-instructor interaction, easy access to diverse educational resources, and interactive learning experiences. [76]. Moreover, the incorporation of technology into teaching and assessment has led to increased student pass rates, reflecting its positive influence on learning outcomes, this narrative highlights the transformative power of technology in ISE, offering dynamic and effective learning experiences that prepare students for the rapidly evolving digital landscape [77, 78].

4.4. Student-Centred Learning

The study findings highlight the significance of teamwork in ISE, as most students recognise its importance, citing reasons such as real-world relevance, skill development, optimal skill utilisation, efficiency, and enhanced learning [79, 80]. Similarly, a combination of the jigsaw and peer-to-peer teaching approaches for programming instruction in a systems development course was introduced, resulting in improved student learning and the alleviation of programming-related fears [81, 82]. Moreover, the introduction of the Lecturer-Chatbot, an AI tool offering personalised guidance to students, underscores the urgent requirement for such technological support in assisting struggling learners [83]. In South African higher education, the research demonstrates the relevance of levels of learning and reflection in experiential learning assignments, where establishing a clear connection between these levels and student motivation, student-centred experiential learning assignments can promote deep learning and reflection, but necessarily requires students to engage with the assignment in a meaningful way [84].

A strong preference for online self-reflective assessments was revealed among first-year students, with an average favouring this approach over traditional classroom tests [85]. Generation Z's reliance on peers for assistance was emphasised, challenging the notion of underdeveloped social skills due to technology use [86]. A strong correlation between online self-assessments and final grades was demonstrated, countering the Ebbinghaus forgetting curve and highlighting the benefits of regular self-assessment [50]). Finally, it was indicated that, despite initial unpopularity, the study buddy system had a positive impact on pass rates, which students prefer, due to the comfortability of studying with peers [88]. These insights collectively underline the value of student-centred learning, and collaborative strategies to enhance the learning experience in ISE in South Africa [89].

4.5. Industry Engagement & Partnership

The findings emphasise the challenges inherent in developing fixed or rigid curricula in ISE, given the rapid advancements in digital technology and their impact on human behaviour and organisational performance [67]. It becomes evident that ISE requires continuous monitoring of technology trends and a flexible approach to curriculum development [90]. The studies also shed light on the role played by Industry Advisory Boards (IABs) in bridging the gap between academia and industry [91]. The research indicates that IABs typically consist of diverse members, including school or departmental representatives, alumni, industry professionals, and student representatives. These boards serve as a valuable platform for networking and collaboration between academia and industry, enabling a fruitful exchange of ideas and insights [92].

Furthermore, the findings highlight the importance of creating structures and administrative guidelines, such as the proposed South African IT Diplomas' Advisory Board (SAITDAB), to manage IT diploma programmes effectively, this initiative is met with strong support from respondents, emphasising the need for collaboration between universities and universities of technology to develop core Body of Knowledge (BOK) standards for IT diploma programs [93]. Overall, the narrative that emerges from these findings highlights the role of industry engagement and partnerships in shaping ISE. It emphasises the importance of adaptability, collaboration, and the establishment of structures to ensure that ISE remains relevant and responsive to the ever-evolving demands of the IT industry [91]

4.6. Accessibility and Inclusiveness

The findings on the South African state of ISE underline the importance of creating an inclusive digital learning environment that accommodates students with disabilities and diverse abilities [94]. Many e-learning websites, including those associated with institutions like Unisa and myUnisa, often fall short of satisfying usability principles for participants with limited hand functioning and visual disabilities [94]. The research emphasises the need for proper implementation of usability principles to enhance the usability of websites, which is crucial for accommodating a diverse student population [95]. Furthermore, the studies emphasise the importance of recognising and addressing the diverse abilities and characteristics of students, including those with disabilities [95]. E-learning websites must be advanced in a way that considers the diversity of characteristics and abilities of different individuals [91]. This approach ensures that educational resources and materials are accessible to all, promoting inclusivity and equal educational opportunities [96].

Additionally, the findings challenge some preconceived notions, such as the impact of cultural diversity on team communication in software development, while there was a hypothesis that cultural diversity might decrease communication within a team, the research results indicate that ethnically diverse teams may exhibit a level of cohesion comparable to or even higher than ethnically homogeneous teams [97]. These findings highlight the complexity of the relationship between cultural diversity and team dynamics, emphasising the need for a nuanced understanding [98]. Lastly, in the context of visually impaired students, the research sheds light on the challenges they face in accessing educational content. Visually impaired students often need to invest

more effort and time to access information, which can create disparities in their learning experiences [99].

4.7. Graduate Education in Information Systems

Findings from graduate education IS research reveals several important aspects of postgraduate studies in this field. First, the research suggests that postgraduate offerings align with participants' preferences [100]. However, some discomfort was noted among participants, particularly in relation to certain dimensions of the offerings. This discomfort suggests that there may be room for improvement in guiding students through the process of internalising complex concepts and conducting research effectively [101]. Secondly, the findings highlight the challenges associated with completing postgraduate IS studies. Despite these challenges, the expectations of students are generally being met, and they perceive the value of their postgraduate education.

The students reported that their knowledge and learning experiences exceeded their initial expectations. This positive perception underlines the significance of postgraduate ISE and its potential to provide students with valuable skills and knowledge that go beyond their expectations [102]. Finally, [40] identified research barriers experienced by South African academics in IS and Computer Science, including time constraints, inadequate institutional support, and gender disparities, underlining the challenges faced by researchers in the field [40]. Lastly, the research provides insights into the methodologies commonly used in postgraduate IS studies in South African HEIs. The most popular methodologies include literature reviews, data analysis, case studies, descriptive/exploratory surveys, conceptual analysis, Design Science Research (DSR), and proof of concept. Understanding these preferred methodologies can guide educators and researchers in selecting appropriate approaches for postgraduate IS studies [103].

5. Conclusions and Future Research

The Research on ISE in South Africa highlights the imbalance between pedagogy and curriculum. It calls for tailored research on innovative teaching approaches for less-resourced institutions. Strategies include collaboration with organizations for real-world scenarios and leveraging open-source ERPs like OpenERP and ESEFA to reduce costs. These strategies empower students despite resource limitations and enhance the quality of education [13]. Accessibility and inclusiveness are noted as critical yet underrepresented topics needing further exploration. While the study is limited to two conferences, future research should broaden its scope for more comprehensive findings. Overall, the study emphasises the importance of ongoing research to enhance the quality and inclusivity of ISE in South Africa, meeting evolving industry demands and diverse student needs.

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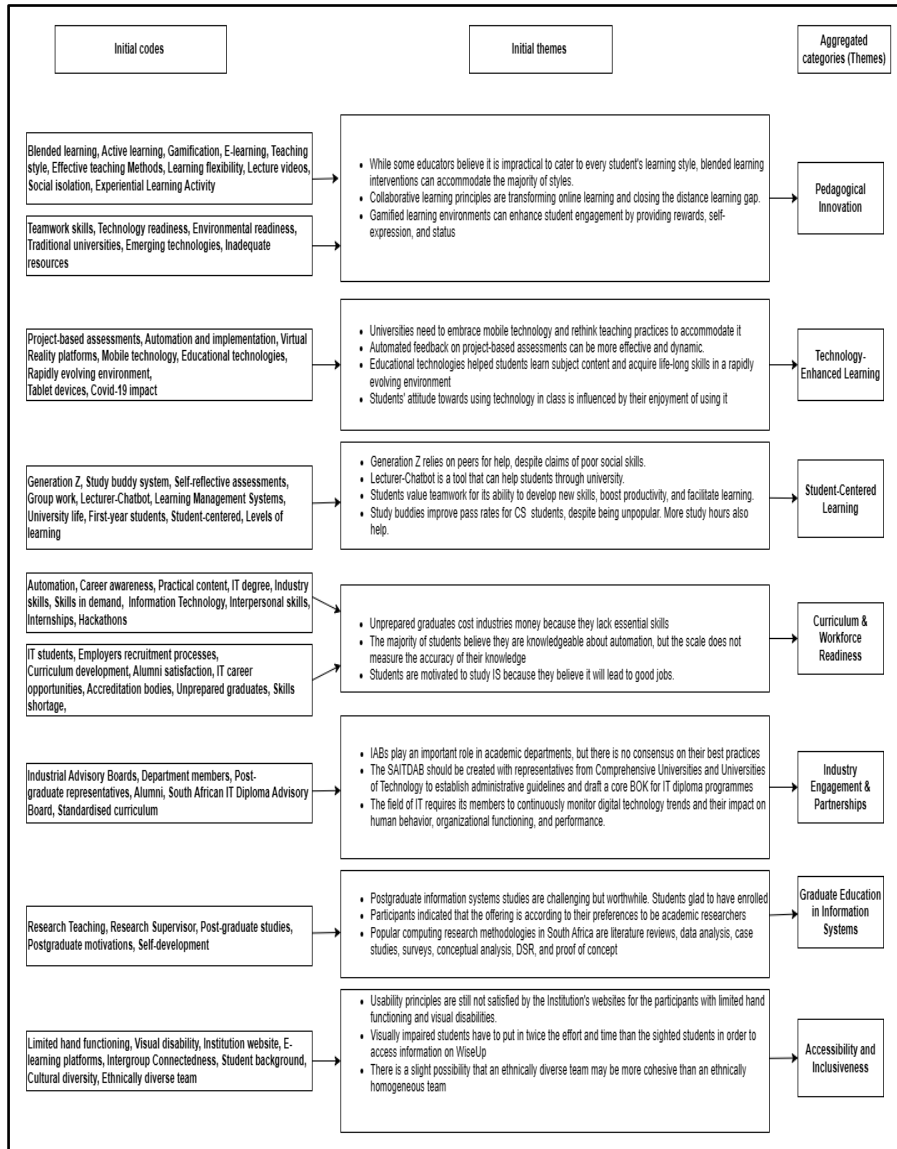
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Appendix



Appendix A: Evolution of data analysis from codes to themes

Usage of a Learning Management System for Assessments in Higher Education: A Scholarly Personal Narrative

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Abstract. A key component of curriculum and instruction is assessment, as it outlines effectively how students learn and what they accomplish. It has the greatest influence on how students see higher education and all they learn there. How we assess our students is important, as it reflects their learning and our teaching. Assessment feedback provides students with the opportunity to improve their learning, and academics to improve their teaching. However, traditional ways of assessing students take up a lot of time. More time is spent setting question papers, marking and capturing marks. As a result, academics either prioritise teaching and assessment without feedback, leading to misalignment of teaching, learning, and assessment (TLA) with the intended learning outcomes (ILOs) and hindering student learning. The TLA must be aligned to achieve the ILOs and ensure our curriculum is constructively aligned. This therefore requires academics to plan effectively, work smart and be innovative in assessing students. Thus, the use of educational technologies such as the Learning Management System (LMS) can aid us in our work, especially with assessments. This paper aims to outline how an academic used Blackboard LMS to assess students, as well as its benefits using a scholarly personal narrative methodology. The paper provides questions that were constructed for the assessment, a summary of student performance and how the assessment aligns with the ILOs. The use of LMS-based assessments significantly reduced the time to mark, which provided the academic more time to analyse students' results and provide constructive feedback in good time.

Keywords: Assessments, Educational Technology, Higher Education, Learning Management System (LMS), Scholarly Personal Narrative (SPN).

1. Introduction

Although curriculum may be the focus of the university, it is impacted by teaching, learning, assessment (TLA), and university outputs [1]. A key component of both the curriculum and instruction is assessment, as it effectively outlines how students learn and what they accomplish, and it has the greatest influence on how students see higher education and all they learn there [2]. Assessments have always been an integral part of the education system and are used for many reasons, such as to determine students' competencies, motivate students, select students for certain programs or courses, award qualifications and meet the standards set for quality assurance [3]. In addition, assessments help us to determine if our curriculum and teaching methods are

responsive, as they provide the two most important aspects: formative feedback and summative grading; therefore, what and how students learn are influenced by how they believe they will be evaluated [3].

Despite the type of assessment, elements such as assessment tasks, learning outcomes, standards, criteria for marking, assessment methods, assessment activities, marks, feedback, and institutional requirements must be considered [4]. To ensure the quality of our assessments is maintained, assessments must be valid, reliable, transparent, equal, comparable and consistent [5].

However, the Covid-19 pandemic saw a drastic shift in how we conduct teaching, learning and assessment. Suddenly, higher education institutions shifted from face-to-face to fully remote and online teaching and learning [6]. Advances in technology have led to an increase in the use of digital platform learning procedures and educational purposes [7]. Different educational and digital technologies (such as LMSs) were introduced at a rate which left many of us still figuring out how to use these technologies in our teaching.

This paper therefore aims to provide an academic's personal perspective and experience with the use of LMS for assessments to change the perspective or norm of utilising the LMS just as an information depository tool and to encourage further use of LMS-based assessments by academics to work efficiently and effectively. In addition, academics can explore the various features and tools offered by LMSs, however, for the scope of this paper, I will focus on the assessment feature of the LMS.

In the following sections, a literature review on LMSs is provided, the methodology utilised, a little of my background tying it to the use of LMS-based assessments and providing examples from one of the assessments I set using Blackboard LMS, its alignment with the intended learning outcomes of the module, the performance of the students, an analysis of assessment questions, and a conclusion with the lessons learnt and the benefits experienced with using an LMS-based assessment.

2. Learning Management System

An LMS is a web-based digital learning platform used for creating, delivering and developing learning content for students [8, 9]. LMSs are good for supporting a wide range of pedagogical and course administration and provide numerous tools and features such as course, user and content management, communication, assessment, and feedback to facilitate traditional teaching activities in web-based learning environments [8, 10]. Benefits of LMS include instant feedback to students, flexibility, accessibility, automated marking, and lower costs in terms of reduction in printed paper for assessments [11]. Academics can choose between quiz- or assignment-based assessments based on the purpose of the assessment [6]. One of the most utilised educational technologies by many universities across South Africa and globally, in business and government is the Blackboard Learn LMS [12].

According to Boston University's TechWeb [13], Blackboard Learn serves as the main learning management system (LMS) for both on-campus and off-campus courses, certificate programs, and clerkships. This demonstrates how widely used Blackboard is in a variety of educational contexts, highlighting how it helps with teaching and

learning activities [13]. Launching its learning management system on Blackboard, the National Highway Institute (NHI) of the Federal Highway Administration demonstrated the platform's adaptability to a variety of industries outside of traditional education [14]. Blackboard Learn is also acknowledged by Sam Houston State University (SHSU) as an essential LMS for online instruction and communication, emphasising its value in meeting a range of learning requirements [15].

Despite the wide adoption and advantages of the Blackboard LMS by universities, many academics think that this online environment has virtually stayed the same as a content repository for handouts, syllabi, and traditional assignments [11]. In addition, despite an LMS's benefits for the teaching and learning process, neither academics nor students have completely realised its full potential yet, suggesting that many of an LMS's integrated features, tools, and functionalities – along with their online assessment feature – are not fully explored and utilized [11].

Incorporating the use of educational technologies such as LMSs can save academics more time and help them to focus on improving their pedagogy and participate in other core elements – such as research and community engagement – of the university.

3. Methodology Used (Scholarly Personal Narrative)

I apply a scholarly personal narrative (SPN) research methodology. This approach is a constructivist research methodology that recognises the researcher's personal experience as a valid object of study [16]. It allows the academic as an information systems/technology (IS/IT) researcher to reach a larger audience and to go beyond the scientific language and purely objective perspective that all too frequently isolate this research field from the rest of academia, practitioners, and the public [16].

The inside-out methodology of SPN sets it apart from other self-interrogation approaches, whereby it starts with the scholar's narrative before turning outwards to help the writer and reader grasp the world outside of the scholar-storyteller better [17]. Swart [18] denotes that SPNs are not just intellectual, but also convey the “storied lives” of professionals, presenting their own unique realities and provoking readers to question their own realities, and is thus a recognised research methodology that uses the author's experiences as a theoretical lens. Moreover, Ng and Carney [19] suggest that the integration of SPN could enhance the Scholarship of Teaching and Learning (SoTL) pluralism and advance understanding of the intricate settings and influences that mould educators, classrooms, and student experiences.

4. My Story

I am a lecturer in training to become a qualified Higher Education (HE) teacher. In all my years in HE and being a lecturer, I have never received any formal or informal training whatsoever on teaching until 2022 when I enrolled for a Postgraduate Diploma in Higher Education (PG_Dip in HE).

Prior to this qualification, I neither understood nor knew why I assessed students and how to assess students. I assessed students the way I saw it being done when I was a student. This approach was misaligned with the purpose of HE in South Africa as well

as the purpose of assessments. It had a negative impact on my practice as I made the assessment to be a battle between the students and I to show who knows better. The aim of my assessments was not to assess student learning, but to wage war between the students and I, and get a high pass rate just to tick the box. However, this way of assessing students is not effective, as it is misaligned with the ILOs and the curriculum itself. As an academic, not understanding the purpose of assessments in HE placed my students in a very hostile environment. In addition to this, I did not provide any feedback whatsoever regarding the outcomes of the assessments, nor did I reflect on how I assessed my students. In so doing, I did not improve my pedagogy. The situation became even worse during Covid-19 as I totally lost my interest in and passion for teaching and students because of issues with an unstable network connection, lack of devices, loadshedding, lack of data, student protests, unending changes of the academic calendar, overload of information and student insults.

However, since having enrolled for the PG_Dip in HE, I have never been so passionate about teaching and students as I am right now. I now see the bigger picture of HE and the importance my role as an academic plays in the students' lives to ensure that they are critical, reflective, independent individuals who are employable and play their role in solving the societal challenges in our country. My perspective on teaching and learning, assessments and higher education has taken a turn for the better. My understanding of what it means to be in higher education and what higher education is about changed drastically and I had to reflect on and change my pedagogy. Although I have not completed the qualification, my application of what I was taught and the knowledge I have gained in this qualification have transformed my philosophy and influenced my SoTL and assessment practices.

With regards to assessments, please understand that I have always assessed students electronically since I have been a lecturer. I never had to deal with handwritten assessments (except when I have to moderate for examinations). That is why, for me, having to mark handwritten assessments was the worst thing I have ever experienced in my years as a lecturer. In April 2023, I had about 89 scripts to mark for a Main Test out of 70 marks. The marking seemed endless. It was a tiring and daunting task. I told myself, "Never again will I take myself through such torture." This horrible experience, along with the workshops conducted for academic development by the Center for Innovation in Learning and Teaching (CILT), the knowledge gained from the PG_Dip in HE and being in the IS/IT field pushed me to make use of educational technologies such as an LMS to assess student learning. I therefore see it fit for me to share my experience on the use of LMS-based assessment to encourage other academics to make use of this and other technologies.

My experience with LMS-based assessments was mostly positive and relieving, coupled with a few challenges here and there, which I was able to overcome. LMS-based assessments also help with massive classes. The eight hours or more I would have spent marking scripts, I managed to remove completely as I had no marking to do. The marking was automated, and immediately provided students with their marks once they completed the assessment.

In the next sections, I will focus on the assessment I set for my second-year Diploma in Computer Networking students to provide a practical example of an LMS-based

assessment, and alignment of the assessment with the module's ILOs, summary of student performance, analysis of the assessment questions, benefits of LMS-based assessments and lessons learned.

5. LMS-based assessment

Earlier, I planned to assess students practically, whereby students will have to apply their knowledge and be hands-on, then answer questions based on what they have done. However, seeing that students had to download and import a virtual machine (VM) of about 3GB in size, this was a challenge and time-consuming because the VM would be downloaded by all students at the same time for them to proceed with their assessment. I then decided to conduct the assessment using an LMS to assess students. Assessing students practically electronically is not easy; it requires one to be innovative to structure the questions in a manner that will still assess the student's ability to apply their knowledge practically. Therefore, an LMS-based assessment may not work well for other practical/technical modules.

5.1. Setting the assessment: Practical Test (PT)

The PT took place on the 19th of May 2023. The challenge I had was with the formulation/creation of questions. I had underestimated the amount of time it required to set up the questions. This task required me to put more effort into structuring the questions to avoid having questions that would require me to mark the answers. I spent most of the time formulating the questions for the PT. As presented in Fig. 1, you can see from the LMS report for the period 01 – 31 May 2023, that I spent 32% of the time on the PT. This was due to the fact that it was my first time utilising an LMS for assessment, and had to learn as I compile the PT.

Once I had formulated the questions along with the answers, everything else easily fell into place. It is important to define what is it you are assessing (the "Why and What" of the assessment); this will help you when you set the assessment. I refined the assessment and made the necessary settings for the PT before I made it available to students. The PT took place in a class setting, was invigilated, password protected, and assessment questions were randomised for each attempt, meaning that the first question for a certain student may appear as the third or last question for another student. There are other options one can select (depending on one's module and assessment) when setting up the assessment to ensure one maintains quality.

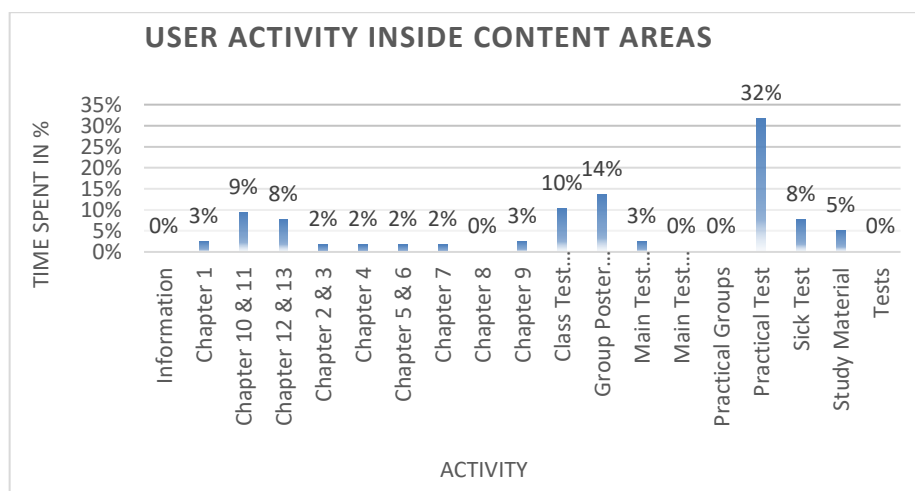


Fig. 1. User Activity

Assessment questions. The test feature of the LMS offers an opportunity of creating different types of questions such as Multiple-Choice questions (MCQs), True/False (T/F), Matching, Fill In, etc. Here I provide different types of questions I included in the assessment to show an example of each and the settings I applied to each to ensure assessment integrity and quality. The assessment referred to in this paper consisted of a combination of MCQs, T/F, Multiple-Answer questions, and Matching. To minimise students copying from one another, I set the answers to be displayed in a random order for MCQs, Multiple-Answer questions and Matching questions.

Figure 4 illustrates an MCQ; Figure 5 presents T/F questions; Figure 6 shows multiple answer questions and Figure 7 illustrates a Matching type of question. For better viewing, these figures (Fig. 4 – 7) are presented in the Appendix.

Alignment of assessment with Intended Learning Outcomes (ILOs). The module I set the assessment for consists of fourteen main intended learning outcomes with multiple specific learning outcomes, which are covered over thirteen chapters. Of these main ILOs, seven of them were assessed during the practical test. According to Biggs [20], constructive alignment is important in higher education as it ensures that there is an alignment between the ILOs, Teaching and Learning Activities (TLA), and Assessment Tasks (ATs). The PT was aligned with 7 of the main ILOs of the module as shown in Table 1.

Table 1. Alignment of Practical Test with Intended Learning Outcomes (ILOs)

ILO No.	ILO Description	ILO Assessed
ILO1	Create a safe environment for implementing and analysing cybersecurity threat events by installing and using virtual machines.	✓
ILO2	Understand the role of the Cybersecurity Operations Analyst in the enterprise through research and analysis of the SOC and requirements to become a Cybersecurity Analyst.	
ILO3	Understand the Windows Operating System features and characteristics needed to support cybersecurity analyses by describing the history and architecture of the OS and how to secure, configure and monitor Windows.	✓
ILO4	Determine the features and characteristics of the Linux Operating System by implementing basic Linux security.	
ILO5	Analyse the operation of network protocols and services by explaining how protocols enable network operations, and how Ethernet and IP protocols support network communication.	✓
ILO6	Understand the operation of the network infrastructure by analysing how devices and services are used to enhance network security.	
ILO7	Classify the various types of network attacks by describing types of malware and classification of three major categories of attacks.	
ILO8	Use network monitoring tools to identify attacks against network protocols and services.	
ILO9	Understand how to prevent malicious access to computer networks, hosts and data by providing approaches to network security defence.	
ILO10	Determine the impact of cryptography on network security monitoring by using the public key infrastructure (PKI).	✓
ILO11	Describe how to investigate endpoint vulnerabilities and attacks by generating a	

ILO No.	ILO Description	ILO Assessed
	malware analysis report from a malware analysis website.	
ILO12	Evaluate network security alerts by identifying the structure of alerts and how they are classified.	✓
ILO13	Analyse network intrusion data to identify compromised hosts and vulnerabilities.	✓
ILO14	Apply incident response models to manage network security incidents.	✓

6. Student Performance and Analysis of assessment questions

There were 96 students enrolled for the module. Of the 96 students, 88 students took part in the assessment, plus 1 student who wrote an aegrotat test for the PT, bringing the total to 89. Of the 89 students who took the PT, 77 students obtained a mark of 50% and above, while 11 students obtained a mark below 50%, bringing the pass rate for the assessment to 80%. Fig. 6 shows the distribution of marks from 0% – 100%.

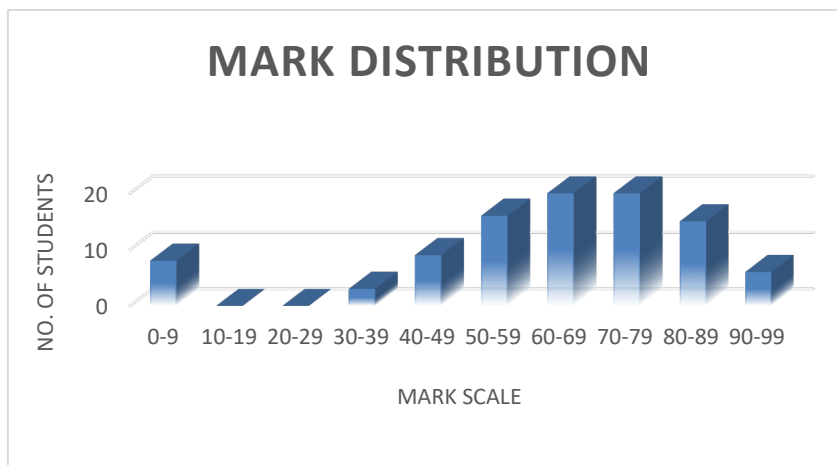


Fig. 2. Summary of Mark Distribution

Table 2 presents the performance of students, with majority of students having obtained a mark between 60% – 79. The 8.2% of students who obtained a mark of 0% – 9% are those who did not take the assessment and therefore obtained a 0 for the assessment.

Table 2. Student Performance

Mark Range	No. of Students (in %)
0% – 9%	8.2%
30% – 39%	3.1%
40% – 49%	9.3%
50% – 59%	16.5%
60% – 79%	41.2%
80% – 89%	15.5%
90% – 99%	6.2%

Having obtained the student results, I was able to run an “Item Analysis” of the PT. This feature analysed the questions of the assessment based on the performance of students on a specific question and provided a report on the level and quality of the assessment questions. Fig. 7 shows the test summary on the quality of the assessment, based only on the 88 students who took the original PT.

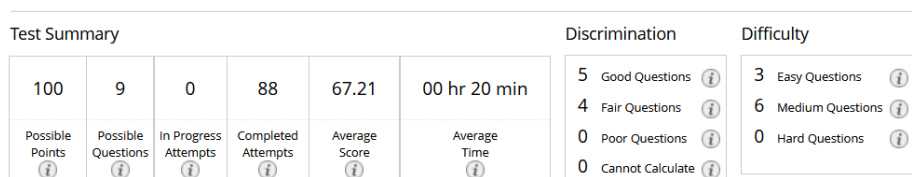


Fig. 3. Assessment Item Analysis

In terms of the quality of questions, 5 of the questions were “Good Questions”, while 4 were “Fair Questions”. Regarding the level of difficulty of the questions, 3 were “Easy Questions” and the rest of the questions were deemed to be “Medium Questions”. Based on the analysis and the performance of the students, the assessment went very well and was at the right level for second-year diploma students.

7. Conclusion: Lessons and Benefits of LMS-based assessments

LMSs provide a wide range of features that can be utilized to aid academics to improve and better manage our teaching, learning and assessment. However, it should be noted that although the assessments are electronic/online, it does not mean they are automatic by default. One must not underestimate the time it requires to set up a test on an LMS. Here are a few tips if you want to use LMS-based assessments:

- Always plan your assessments ahead of time, because setting up the questions on the LMS requires time for you to edit, modify, and test the questions to ensure they are suitable for the assessment.
- Ensure you set security and time parameters for your assessments such as providing a password for your students, and then change the password once everyone has logged in to ensure that even if the password is leaked, a new password is in place. One must always be prepared for such situations.

- If you have multiple classes running at the same time, make use of your student assistants. Ensure they understand what should happen and monitor the classes as the lecturer. It is your responsibility. Communication between you and your student assistants is key.
- In an event where you have a massive class and not enough space in the venue to accommodate all the students, you need to group students and have the assessment running in different sessions or timeslots and ensure you set a different password for each session and implement tip number 2 above for each session.
- Always do a head count against the number of students on the attendance register and the number of students who take the assessment/are in class.
- For future use, one can create bulk questions which can be used again for assessments and add to them every year to avoid repeating questions. Despite advances in technology, LMS-based assessments still need to be monitored and invigilated to ensure assessment quality and integrity are maintained.

There are many benefits of utilising an LMS effectively. Firstly, it saved me a lot of time as I had no marking to do because the marking was done automatically by the LMS. Secondly, with the report feature provided by the LMS, I was able to pull up reports which assisted me in analysing the assessment questions and student performance for each assessment question. This feature provides me with the opportunity to know in which areas my students need improvement and provide them with proper feedback regarding their assessment results. In addition, I saved my institution a lot of paper because the assessment was electronic. I did not have to print any question papers and provided students with hardcopy answer sheets. The only negative aspect about the current version of the LMS is that it is not appealing, easy to use (involves a lot of steps to do a certain task) and some of the features are not easily understandable, but it is workable, and with practice and training one can utilise it effectively. I believe the newer versions will be much more user-friendly and improved.

In conclusion, learning management systems provide a variety of tools and features which we can leverage to aid us in our teaching, learning and assessments. It can also be used to generate reports on students' performance and activities to help monitor students' progress and engagement. It is therefore a good tool to utilise as an academic for managing the administrative aspects of one's modules too. I recommend that academics equip them with training provided by their institutions on the use of LMS so that they can utilise and incorporate the LMS for teaching, learning and assessment. One can also supplement the use of LMS with other educational technologies to bridge the gaps left by the LMS for improved teaching, learning, student engagement and assessment.

The element of LMS-based assessments I covered in this paper only touches the tip of the iceberg. The use of educational technologies should be embraced even more now that we are in the digital age. The world is moving forward, and we must keep up with it, otherwise we get left behind. Introducing educational technological tools such as an LMS is only the beginning, as there is a whole world of these tools to explore. We must open ourselves up to learning how to use LMSs to aid us in our work as academics. Let us embrace the technological tools we have been provided with to come up with

innovative and sustainable ways to assess our students' learning better so they, as well as us, can improve. One educational technology tool at a time is all it takes, but we must be willing to embrace change to bring about change in what we do.

Declaration. This paper was edited by an accredited language practitioner. Proof can be provided on request.

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Appendix

Question 6

15 points

Save Answer

On a web browser, using the Advanced Encryption Standard (AES) symmetric encryption algorithm, decrypt the following encrypted message using the key "Analyst" :

L9X2e68nc603opvZj71z4ByB6qzHHdmFoDp8WrbAolnExyeZmjKOWWM6fOMt4jBl6DUrsb9gH7t8qOisNqXBqLf3XTDfcdnV1jTuBtGTYE=

What does the message mean?

- 1. Encrypting messages is one of the ways of maintaining data integrity
- 2. Encrypting messages is one of the ways of maintaining data integrity.
- 3. Encryption of messages is one of the ways of maintaining integrity.
- 4. Encryption of messages is one of the ways of maintaining data integrity.

Fig. 4 MCQ

Question 3**10 points**

Save Answer

TRUE or FALSE: Consider the image below. The first output line displays the Fully Qualified Domain Name (FQDN) e2867.dsca.akamaiedge.net, and this is followed by the IP address.

```
C:\Users\nnomabhongo>ping www.cisco.com

Pinging e2867.dsca.akamaiedge.net [104.75.192.162] with 32 bytes of data:
Reply from 104.75.192.162: bytes=32 time=21ms TTL=55
Reply from 104.75.192.162: bytes=32 time=38ms TTL=55
Reply from 104.75.192.162: bytes=32 time=37ms TTL=55
Reply from 104.75.192.162: bytes=32 time=39ms TTL=55

Ping statistics for 104.75.192.162:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 21ms, Maximum = 39ms, Average = 33ms
```

- True
- False

Fig. 5. T/F

Question 9

10 points Save Answer

Consider the images below. The same website (www.cisco.com) was pinged, however, the FQDN and IP addresses are not the same. Select ALL reasons why this is so:

```
C:\>ping www.cisco.com

Pinging e144.dscb.akamaiedge.net [23.1.48.170] with 32 bytes of data:
Reply from 23.1.48.170: bytes=32 time=56ms TTL=57
Reply from 23.1.48.170: bytes=32 time=55ms TTL=57
Reply from 23.1.48.170: bytes=32 time=54ms TTL=57
Reply from 23.1.48.170: bytes=32 time=54ms TTL=57

Ping statistics for 23.1.48.170:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 54ms, Maximum = 56ms, Average = 54ms
```

```
C:\Users\inmomabhongo>ping www.cisco.com

Pinging e2867.dscb.akamaiedge.net [104.75.192.162] with 32 bytes of data:
Reply from 104.75.192.162: bytes=32 time=21ms TTL=55
Reply from 104.75.192.162: bytes=32 time=38ms TTL=55
Reply from 104.75.192.162: bytes=32 time=37ms TTL=55
Reply from 104.75.192.162: bytes=32 time=39ms TTL=55

Ping statistics for 104.75.192.162:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 21ms, Maximum = 39ms, Average = 33ms
```

- 1. Depending upon where you are geographically, the FQDN and the IP address will be different.
- 2. Depending upon your status and account, the FQDN and the IP address will be different.
- 3. Cisco hosts the same web content on different servers throughout the world (known as mirrors).
- 4. Cisco hosts different web content on different servers throughout the world (known as opposites).

Fig. 6. Multiple Answer Question

Question 5

15 points Save Answer

Computer security incident response has become a vital part of any organization. The process for handling a security incident can be complicated and involve many different groups. An organization must have standards for responding to incidents in the form of policies, procedures, and checklists. Consider the following scenarios and apply your knowledge of security incident handling procedures to formulate questions about the given incident scenarios.

Scenario 1: Worm and Distributed Denial of Service (DDoS) Agent Infestation

This scenario is about a small, family-owned investment firm. The organization has only one location and less than 100 employees. On a Tuesday morning, a new worm is released; it spreads itself through removable media, and it can copy itself to open Windows shares. When the worm infects a host, it installs a DDoS agent. It was several hours after the worm started to spread before antivirus signatures became available. The organization had already incurred widespread infections. The investment firm has hired a small team of security experts who often use the diamond model of security incident handling.

Scenario 2: Unauthorized Access to Payroll Records

This scenario is about a mid-sized hospital with multiple satellite offices and medical services. The organization has dozens of locations employing more than 5000 employees. Because of the size of the organization, they have adopted a CSIRC model with distributed incident response teams. They also have a coordinating team that watches over the security operations team and helps them to communicate with each other. On a Wednesday evening, the organization's physical security team receives a call from a payroll administrator who saw an unknown person leave her office, run down the hallway, and exit the building. The administrator had left her workstation unlocked and unattended for only a few minutes. The payroll program is still logged in and on the main menu, as it was when she left it, but the administrator notices that the mouse appears to have been moved. The incident response team has been asked to acquire evidence related to the incident and to determine what actions were performed. The security teams practice the kill chain model and they understand how to use the VERIS database. For an extra layer of protection, they have partially outsourced staffing to an MSSP for 24/7 monitoring.

Match the correct questions about the given scenarios above with the correct incident handling procedure.

- Preparation
- Detection and Analysis
- Containment, Eradication, and Recovery
- Post-Incident Activity

1. What indicators of the incident might the organization detect? Which indicators would cause someone to think that an incident might have occurred?
2. Would the organization consider this activity to be an incident? If so, which of the organization's policies does this activity violate?
3. What could be done to prevent similar incidents from occurring in the future?
4. What strategy should the organization take to contain the incident? Why is this strategy preferable to others?

What sources of evidence, if any, should the organization acquire? How would the evidence be acquired? Where would it be stored? How long should it be retained?

Fig. 7. Matching

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The Influence of Player Type on the Motivation of Students in a Gamified Programming Learning Environment

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Abstract. The integration of gamification principles into programming education can bolster student motivation, engagement and learning outcomes. However, a one-size-fits-all model, which treats all students as a homogeneous entity, is not an optimal gamification design approach. Insight into player types among students offers a valuable understanding of their engagement with gamified experiences and facilitates the customisation of design elements so that they align more closely with their preferences and motivations. The current study aimed to investigate how different game elements influence the motivation of students who represent different player types in a gamified first-year internet programming module. The dynamics mechanics components model and self-determination theory were used to design the gamified learning environment of the study and the HEXAD player topology was used to categorise students into different player types. The results of interviews indicate that the philanthropist type had a preference for collaborative learning. Moreover, achievers preferred challenging tasks and solving difficult problems; leaderboards motivated them to work harder. Additionally, socialisers enjoyed socialising with other students the most and were motivated by face-to-face competition. The player type had the greatest motivational desire to be at the top of the leaderboards and also enjoyed face-to-face competition. Lastly, free spirits were motivated the most by being in control of their own learning and creative learning activities; they were also motivated by face-to-face competition in the gamified learning environment. This paper provides valuable insight into how gamified learning environments can be tailored to meet the diverse motivational needs of students.

Keywords: player type, gamification, programming education, higher education, intrinsic motivation, ARCS.

A model towards enabling tutors to fulfil a role in attenuating source code plagiarism

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Abstract. Source-code plagiarism has been a persistent problem in the academic computing environment, but its prevalence intensified due to the disruption caused by the emergency remote teaching and learning that the COVID-19 pandemic enforced. This is especially a concern in the context of teaching novice programmers to code. The pandemic compelled residential universities to accommodate students in ways previously unheard of, even in the context of non-residential establishments. Students found themselves in an environment where preparation for assessments was not necessary since they had access to material, peers and whatever help they could line up to pass. The pandemic is a distant memory, but academia will not return to its pre-Covid status, and to add to this situation, generative artificial intelligence emerged in 2023 as a playmate on this very playground. In this context, tutoring is of utmost importance when teaching novice programmers to code, and therefore it makes sense to learn from past approaches to guide this support function in future. With this premise in mind, an interpretivist perspective was adopted, and qualitative data were gathered, centering on focus group interviews, as well as interviews with tutors unavailable for focus group sessions. These tutors supported classes of introductory programming students over a period of three years. Within this setting, the lecturer-as-researcher reflects on mitigating source code plagiarism holistically. This paper aims to propose a model to enable and support tutors in their role to attenuate source code plagiarism.

Keywords: Academic integrity, Novice programming, Source code plagiarism, Tutoring

Inquiry into the Paradox of an ICT Skills Gap

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Abstract. Industry labours under chronic IT skills shortages, despite burgeoning graduate unemployment. This presents a paradox, frequently diagnosed as a simple matter of skills mismatch. Its stubborn persistence, though, notwithstanding decades of sustained interrogation, suggests that a more complex web of factors may be at play.

An exploratory literature review of relevant theoretical approaches is undertaken with the aim of expanding the range of factors to be considered in subsequent inquiries into the skills gap. The review proceeds from the specific to the general, interrogating Job Matching Theory, Human Capital and Signalling Theory, Institutional and Resource Dependence Theory, Social and Cultural Capital Theory and Structural Hole Theory. Salient concepts from each are introduced, and their implications are extrapolated onto the area of concern.

A central theme of trust in the face of uncertainty emerges strongly from the review. Interventions are suggested in the light of these findings.

Keywords: ICT Skills Gap · Computer Programmer Recruitment · Graduate Unemployment · Soft Skills.

Bridging Local Realities and Global Goals: Exploring Student-Led Sustainable-Smart Innovation Projects in a Marginalised Community

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Abstract. This study explores the intersection of Higher Education for Sustainable Development (HEfSD), sustainable-smart innovation and the significance of local context in digital technology design, as captured in student-led projects within a marginalised community in Cape Town. As the global imperative to achieve the Sustainable Development Goals (SDGs) intensifies, integrating sustainable practices and innovative technologies at the local and community scale becomes paramount. This research investigates the potential of collaborative educational approaches in addressing complex sustainability challenges through the lens of a specific Cape Town community. The paper provides findings from the third iteration of a longitudinal Design-Based Research (DBR) study. Data includes interviews, participatory observations, and project artefacts. This research seeks to identify the enablers and barriers to validate an additional design principle for implementing sustainable-smart student projects. It examines the collaborative design thinking process, interdisciplinary approaches, and community engagement employed by students and educators to co-create sustainable-smart innovations that respond to both local challenges and global sustainability goals. By doing so, this study sheds light on the potential of HEfSD to nurture sustainable-smart innovation within unique socio-economic and cultural contexts. The research underscores the need for higher education institutions to embrace localised, student-centred initiatives that harness the power of innovation to drive positive change in marginalised communities, thus advancing both sustainability and social equity agendas.

Keywords: Information Systems Education, Sustainable-Smart Solutions; Higher Education for Sustainable Development, Local Knowledge; Design Thinking, Innovation-Based Learning.

Reflections on Leading and Managing Computer Science Final Year Projects in a South African Rural University using Gibb's Framework

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Abstract. Sustainability is pivotal in human endeavours and education has played an important role in ensuring the attainment of sustainable development. Experiential learning has been recognized as viable in achieving sustainability in education, leading to the promotion of practical experiences and activities. The importance of experiential learning and practical application in higher education cannot be overemphasized, especially in technical fields of study, such as Computer Science. The Final Year Project is one of the ways of making experiential learning possible. The Final Year Project is pivotal in shaping students' academic and professional growth. However, the unique context of reflecting on teaching and learning prompted the study of the adapted methods used in teaching, learning and coordinating the final year projects to aid possible improvements that foster inclusive and impactful learning for students. Through a collaborative self-reflective study of the practices and experiences involved in teaching, learning, and coordinating final year projects by two academic staff, this study employed the use of Gibbs reflective cycle as the guiding methodology to offer insight into the challenges faced, strategies employed, and lessons learned in the context of a rural university in South Africa. The reflections highlight benefits such as enhanced student engagement and problem-solving skills. These insights provide practical strategies for instructors to support students better and improve final-year project outcomes, especially in resource-constrained settings.

Keywords: Final Year Projects (FYP), Rural University, Sustainability, Reflective study, experiential learning, South Africa.

Elements to Address in a Computing Research Project Honours Course Module: A Tale of Two Universities

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Abstract. Honours research projects are designed to help novice researchers to make the transition from being taught about and solving practical computing-related problems to doing research. The offering of the subject is unique in the sense that the conventional teaching model is not ideal; its needs are closer to a third-year capstone project module approach, but the situation is more complex and therefore needs special treatment. Typically, these subject modules are not a one-lecturer-does-everything-offering because every student needs guidance to complete their project and to support teaching in a wide variety of research-specific topics. It makes more sense to include a small team of staff members to coordinate honours research projects and to include academic staff as study leaders and topic-specific experts. A compact, two-phase Design Science Research method is utilised to allow a design-as-artefact for each entity under scrutiny as the first phase. This approach accommodates each university as an alternative design. In the second phase, the design alternatives are tested by comparing the results from the alternatives obtained from the two cycles according to requirements. A third Design Science Research cycle-for-demonstration extracts the best practice alternative design. Future research includes implementing the new design at the two participating universities. This paper also extends an invitation to other universities to implement the new design and, in doing so, contribute to the debate and the improvement of future implementations.

Keywords: Design Science Research, Computing, Honours Research Project.

A SOLO-adapted Evaluation Methodology for Quantifying Learning Transitions on Algorithms

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Abstract. Various methods of algorithm evaluation generate feedback on students' progress. Feedback is an important aspect of effective teaching and learning and therefore adequate attention to generating it is essential. Although various methods of algorithm evaluation are discussed in the literature, not much is available on algorithm evaluation methodologies that yield feedback in the form of learning transitions from one algorithm to another. Quantitative methods of evaluation like the allocation of marks to the sections of the algorithms are statistical and do not fully generate a clear view on learning transitions. In this paper, we present a SOLO-adapted evaluation methodology (based on the SOLO taxonomy) that can generate meaningful feedback on learning transitions (learning progression) between algorithms. The SOLO-adapted evaluation was tested on actual introductory programming students' algorithms at a university. In the experiment, the feedback (learning transitions) generated by the SOLO-adapted evaluation was used to inform pedagogical intervention. The SOLO-adapted evaluation can show learning transitions as either an *improvement*, *intermediate improvement*, *stagnant learning*, *deteriorating learning*, *intermediate deterioration of learning* or *already known*.

Keywords: Teaching, Learning, Feedback, Algorithm, Introductory programming, SOLO, SOLO-adapted evaluation.

Pair programming and underrepresented groups in Information Technology

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Abstract. It's concerning that in a country where the majority of the population comprises Black South Africans, they constitute the minority within the IT industry. Additionally, the issue of gender inequality persists in IT, with females remaining underrepresented both in IT classes and in the workplace. The aim of this study was to examine the impact that pair programming has on shaping the experiences and perceptions of underrepresented minority students in Information Technology (IT) in South Africa. The study included a total of 284 first-year students taking a User Interface programming module. The students were given the opportunity to pick a desired programming partner and for the duration of the semester, they programmed in pairs. At the end of the semester, the students completed a questionnaire. The findings suggested that the group of students had a positive experience with pair programming. However, the underrepresented minority students had an even more positive learning experience with pair programming. The female students (White and Black) and male Black students perceived pair programming in an exceedingly positive light, as it improved their overall programming skills and teamwork skills. It can be recommended that with timely training and adequate implementation of the pair programming principles, all students, but indeed more so the underrepresented minority students in a programming course can reap the benefits of the use of pair programming. This approach may attract and increase the retention rate of underrepresented groups in IT and encourage them to further pursue IT careers in South Africa.

Keywords: Pair Programming, Information Technology, Underrepresentation, Minorities

Towards Integrating Ethics into Computing Curricula: An Active Learning and Cognitive Psychology Approach

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Abstract. Ethical issues in computing have been a concern for longer than the past seven decades. Attempts to address these issues include raising awareness and guiding computing professionals. However, these efforts have not been sufficient to end ethical issues in computing. Teaching computing ethics to students of higher learning institutions is one of the recent trends that attempt to address the problem before professionals reach the job market. While teaching computer ethics is gaining momentum in the West and European countries, there is still no consensus on what and how to teach computing ethics. Furthermore, some countries, like South Africa are still in the infancy stages when it comes to teaching computer ethics. In an attempt to answer this study's research question, the critical analysis of related literature was kept central to the enquiry of this research. The use of active learning and the employ of cognitive psychology principles, to teach ethical theories to computing students, is proposed in this study. The approach is then introduced with an in-principle demonstration of how it works. The research shows that it is helpful to teach computer ethics with the guidance of cognitive psychology principles and that it may also contribute to universities producing ethical computing professionals.

Keywords: teaching computer ethics, ethical theories, active learning, cognitive psychology principles.

Digital Literacy: Challenges and Opportunities

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Abstract. When the #FeesMustFall student movement, successfully swayed the South African Government to introduce free Higher Education tuition in 2017, the biggest obstacle to further education for the majority of matriculants, was removed. Due to the fast-paced world of technology, Higher Education Institutions have significantly changed how learning and teaching are conducted. This was further advanced with the onset of the COVID-19 pandemic when classes were forced to go online. Students and lecturers battled to find a balance between the computer skills needed, and how to use them in a digital classroom. The Institute of Race Relations reported in 2018 that the South African Education system is in crisis and that the learners leaving school are poorly prepared for the world after school. Computer skills are among the essential skills required to be successful in any environment, yet many students find themselves encountering a computer for the first time at university.

The objective of this study is to reflect on the experience of Nelson Mandela University lecturers, in Computer Skills classes over the last seven years. An overview of how the offering of the module has changed will be presented. The lecturers' perceptions of the successes and failures over the same period will be captured; including the observed challenges that students experienced. A possible solution, to the challenges identified, such as lack of digital skills for classroom readiness, time management, and student numbers, which would be suitable at all HEIs, to provide a better learning and teaching experience in Computer Skills classes will be presented.

Keywords: Computer Skills, Digital Skills, Classroom Readiness, End User Skills, Online Learning, Blended Learning.

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