An Investigation into the Relationship between Design Approaches, Meaningful Engagement, and Agency in a Blended Learning Computer Science Theory Course

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Abstract

Disengagement among learners in tertiary Computer Science (CS) courses, particularly those focusing on algorithmic design, poses challenges to the achievement of learning outcomes. This study explores the relationship between learning design approaches, meaningful learner engagement, and agency in the context of a blended learning CS theory course at a tertiary level. As technology provides new opportunities for pedagogical practices, gaining insight into how agency and learning design approaches affect learners' experiences has the potential to enhance education in South Africa (SA) and globally.

This study utilises a mixed-methods research design, integrating both quantitative and qualitative data collection techniques. A comprehensive questionnaire (see Appendix A) was administered to learners to determine their perceptions of engagement and agency, assisting in identifying nuances that informed the design and development of learning activities within the course. After the implementation of the learning activities, a second questionnaire (see Appendix B) was administered to evaluate their overall effectiveness. Additionally, in-depth interviews (see Appendix C) were conducted with a subset of participants to capture valuable qualitative insights. The Social Realism (SR) theory of Margaret Archer (1995, 2003, 2006) was used to understand learner agency and their personal concerns that inform their courses of action. Archer's (2007b) analytical dualism approach, which separates culture, structure, and agency, was followed to examine the interrelation between these three dimensions.

The findings of this study reveal an enabling relationship between the incorporation of design approaches and heightened learner engagement. Learners reported a greater sense of motivation, enthusiasm, and connection to the subject matter when certain design methods were integrated into learning activities. Furthermore, the qualitative data highlighted agency among learners, as they assumed more active roles in their learning, ultimately leading to a deeper understanding of algorithm design in CS.

A conceptual framework, the Meaningful Engagement (ME) framework, is presented in this study, providing valuable insights for educators, curriculum developers, and instructional designers seeking to enhance meaningful learner engagement and agency in blended learning environments. Furthermore, this study contributes to the ongoing discourse on the integration of engaging pedagogical practices in higher education, shedding light on the benefits of design approaches in enriching the learner experience and promoting agency that empowers the learner.

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Lastly, I would like to thank my family. To my wife, Jasmine, thank you for your support and patience, enabling me to pursue my educational aspirations. To my young son, Liam, thank you for being a constant source of inspiration and motivation.

"What any person in the world can learn, almost all persons can learn if provided with appropriate prior and current conditions of learning".

- Dr. Benjamin Bloom (1976:7)

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*Please note that, for the purpose of this dissertation, all figures have been designed and developed by the author except for Figures 2.1, 2.2, 2.4, 2.7, 3.2 and Tables 2.1, 2.2, 2.3.

List of Abbreviations and Acronyms

BL	–	Blended Learning
CS	–	Computer Science
CSE	–	Computer Science Education
DBE	–	Department of Basic Education
DMP	–	Data Management Plan
ET	–	Emerging Technology
HOTS	–	Higher Order Thinking Skills
ICT	–	Information Communication Technology
IEB	–	Independent Examination Board
IT	–	Information Technology
LMS	–	Learning Management System
LOTS	–	Lower Order Thinking Skills
LXD	–	Learning Experience Design
ME	–	Meaningful Engagement
NSC	–	National Senior Certificate
NSFAS	–	National Student Financial Aid Scheme
OSE	–	Online Student Engagement Scale
PBL	–	Problem Based Learning
PjBL	–	Project Based Learning
SA	–	South Africa
SCEQ	–	Student Course Engagement Questionnaire
STEM	–	Science, Technology, Engineering and Math
SR	–	Social Realism
TVET	–	Technical and Vocational Education and Training
RQ	–	Research Question

*Please note that, for the purpose of this dissertation, the words: Information Technology (IT) and Computer Science (CS), and learner and student are treated synonymously.

Chapter 1: Introduction

This study investigates the interplay between design approaches, meaningful engagement (ME), and agency of learners. It is most concerned with uncovering enablers (engaging factors) and constraints (disengaging factors) that may explain why learners (dis)engage from the learning process in a Computer Science (CS) first year tertiary course on algorithm design and development. For ME to occur, learning interventions should not only be enjoyable and captivating, but should also foster engagement that goes beyond mere positive interaction. This implies a deeper connection with the learning content and outcomes that result in long term changes in actions and beliefs (Liu et al., 2017; Quinn, 2022).

1.1 Background to the Study

The number of learners who graduate in CS at South African tertiary institutions is low (South African Department of Higher Education and Training [DHET], 2021; Mutanga, 2020). Learners that study CS at tertiary level often find the subject challenging (Simon et al., 2019; Watson & Li, 2014). Statistical analysis of the number of learners enrolled at South African technical and vocational education and training (TVET) colleges in 2019 reveal that of the list of 18 programmes, CS enrolments ranked eighth (DHET, 2021). Moreover, the IT sector is included in the 2020 List of Occupations in High Demand Report, emphasising the need for more skilled IT professionals (DNA Economics, 2020). This concern is echoed by Blade Nzimande (2020), the South African Minister of Higher Education, Science and Innovation, who argues that "we still have a problem in South Africa with too many learners rushing to courses that are oversubscribed, which is breeding unemployment. Furthermore, we are spending a considerable percentage of National Student Financial Aid Scheme (NSFAS) money to support learners who are not going to get jobs at the end of the day because they are in areas that are not in high demand" (Nzimande, 2020).

Given the modest enrolment rate into CS programmes, the issue is further compounded with CS programmes having the third lowest completion rate among the 18 listed programmes (DHET, 2021). A particularly demanding theoretical aspect regarding the study of CS has been identified – the designing and developing of algorithms for programming. This area of study is notably challenging for CS learners to understand, and educators have encountered difficulty in engaging their learners in these sections (Gomes & Mendes, 2007; Havenga & Mentz, 2009; Jenkins, 2002; Koorsse, Cilliers & Calitz, 2015; Medeiros et al., 2019; Thota, 2014). Koorsse, Cilliers and Calitz (2015) note that there is a lack of sufficient engaging resources within the subject area of CS, and this is especially evident in outdated CS theory resources which do not represent current technological and pedagogical trends. Moreover, learners often drown in CS terminology and quickly become disengaged if the resources to teach CS are not presented in an engaging manner (Cheah, 2020).

Therefore, this research investigates learner disengagement in a first-year tertiary course on programming logic and design. This involves the design, development, implementation, and evaluation of digital learning activities to determine if there is a relationship between design approaches and learner engagement within a blended learning environment. Digital learning is discussed as a broader term that encompasses any form of learning that involves digital technologies, including both electronic and mobile learning (Kumar et al., 2018). Social Realism (SR) is used as a theoretical lens with the aim of explaining the influence of agency on learners' engagement or disengagement.

An aim of this research is to create engaging learning experiences (i.e., digital learning activities) that include meaningful structures, patterns, and strategies to enhance both learning and performance. The design and evaluation of digital learning interventions for Science, Technology, Engineering and Math (STEM) practices is a largely understudied area, resulting in the need to tighten the relationship between digital learning research, design, and evaluation (Jaber et al, 2018); moreover, to offer learning interventions that captivate all learners by utilising contextually sensitive methods that foster and motivate individuals to pursue careers in STEM fields. This involves understanding the challenge from the perspective of the ones who are, or are not, engaging: the learner (Blakey & Major, 2019; Boda & Svihla, 2020). Thus, this calls for the need to understand features and elements of learning interventions from the perspective of the learner so that meaningful learner engagement may be promoted.

1.2 Problem Statement

The global landscape of Computer Science Education (CSE) presents notable challenges, particularly regarding learner engagement (Havenga & Mentz, 2009; Vegas, Hansen & Fowler, 2021; Yadav, Gretter & Hambrusch, 2015). Despite the important role CSE plays in equipping learners with essential skills for the job market and promoting logical thinking, problem-solving, and algorithmic reasoning, the uptake of CSE courses remains modest, with low throughput rates (Havenga & Mentz, 2009; Vegas, Hansen & Fowler, 2021).

An examination of CSE in South Africa indicates considerable challenges at both secondary and tertiary levels, where learners encounter difficulties in grasping algorithmic concepts and problem-solving strategies. The research problem therefore centres on identifying effective interventions to enhance learner engagement. This study will investigate pedagogical strategies, the role of agency in the design and development of digital learning activities, as well as the role of agency in the participation and completion of these digital learning activities, and a framework to evaluate and improve learner engagement.

1.3 Context and Rationale: Theoretical Gap

Learners perceive CS as being a difficult and time-consuming subject (Havenga & Mentz, 2009; Koorsse, Cilliers & Calitz, 2015), and although there are aspirations by learners to enter the field of CS, the dropout rate remains high.

It is therefore important that once learners have selected CS, relevant, engaging, and supportive approaches are adopted to retain learners within the subject (Koorsse, Cilliers & Calitz, 2015).

Having taught CS at secondary and tertiary level for over 20 years, personal experience has shown that this is especially evident regarding theoretical components, as CS theory resources (i.e., textbooks) are often out of date, lack the necessary detail, and are unmotivating. The majority of CS learners I have taught enjoyed the practical aspect of CS (i.e., coding), however, the theoretical components tend to be a barrier for learners. Learners have expressed that theory is more monotonous to learn and it becomes difficult for teachers to engage their learners in these sections. A particularly difficult, yet essential, theoretical section for learners is algorithmic design. Within this area, learners need to become familiar with theoretical concepts such as data structures and solving real-world problems using specific algorithms before implementing (coding) these algorithmic designs in a practical sense. Learners experience difficulties with comprehending abstract programming concepts, particularly creating algorithms to address problems (Cheah, 2020; Gomes & Mendes, 2007). In the absence of engaging approaches to teach theoretical CS, learners often lose interest and patience (Cheah, 2020). Furthermore, whilst content is important, inadequate conditions often lead to negative learning experiences and disengagement among learners (Aguilera-Hermida, 2020).

This issue was further emphasised and compounded during COVID-19. Being positioned as a teacher/lecturer at two educational institutions in 2020, a tertiary college and a secondary school, provided insight into teaching and learning before, during, and after the emergency transition to remote learning due to COVID-19. At the beginning of the academic year teaching consisted of traditional face-to-face lessons, then swiftly shifted to 100% online, and then towards the end of the year, a hybrid (face-to-face and online) blended approach was adopted. Reflecting on the different educational periods I observed how learners struggled to adjust in a 100% online environment, and there was a clear preference towards blended learning pedagogies. Furthermore, a greater number of learners appeared disengaged during the 100% online period, and there was a real sense of isolation. As their educator, the year highlighted disparities of equity that exist between learners, resulting in learners disengaging from the learning process. In addition, learners who were once extroverted and engaged in a traditional face-to-face lesson were more subdued and disengaged. This played out particularly in online activities and assignments. PowerPoint slides indicating daily lesson objectives, administrative tasks, video links, and voice recordings placed on Google Classroom were incredibly helpful in offering structure and focus during the transitional stages. However, there was always a sense that more could be done, and how could this “more” be done by using an array of pedagogies and digital technologies to promote learner engagement.

1.4 Research Objectives (Purpose of the Study)

The objective of this study was to understand and determine learners' perspectives on how chosen design approaches impact both learner (dis)engagement and the agency of learners in the context of a CS theory course delivered through blended learning. The objective was to also develop a framework for research and design, with the main theme being a focus on ME. This involved: (1) investigating the relation between design approaches, learner engagement, and learner agency in the blended learning environment of a CS theory course; (2) determining the influence of design approaches on learner engagement; (3) identify (dis)engaging elements by understanding learner experiences with the digital learning activities; and (4) evaluating learner agency influence on (dis) engagement and explaining this relationship by analysing the agency of learners using SR theoretical framing.

1.5 Research Questions (RQs)

1.5.1 Primary RQ

RQ 1: What is the relationship between design approaches, meaningful engagement, and agency in a blended learning Computer Science theory course?

1.5.2 Secondary RQs

RQ 2: What, if any, influence did the use of design approaches have on meaningful engagement?

RQ 3: What experiences and features of the learning activities do learners find engaging or disengaging?

RQ 4: What are the structural and cultural enablers and constraints?

RQ 5: To what extent, if any, did learner agency influence meaningful engagement in this course?

1.6 Brief Overview of Methodology

This study adopts Margaret Archer's SR approach to understanding the role of agency as a means to explain why certain decisions are made by people within a given context (Archer, 2007b). Archer argues that in order to understand the actions of the agent, the researcher should take into account culture (beliefs, ideas, etc.), structure (the context, e.g. institutional policies, a structured learning activity), and agency (concerns, projects and practices). These three dimensions are analysed separately in a methodological approach known as analytical dualism (Archer, 2007b). Only after this separate analysis can the three dimensions be considered together to understand the relationship between them (Archer et al., 1999). These relationships will be discussed in Chapter 5.

A mixed methods approach was adopted, including quantitative and qualitative methods of data collection and analysis. Three rounds of data collection over a semester (five months) were conducted. This consisted of implementation of a questionnaire before the design and development of the learning activities, field notes during the implementation, and a questionnaire and focus group after the completion of the learning activities. These methods enabled findings to be contextualised under relevant themes, revealing the reveal the cultural, social, and

agential enablers and constraints on learner (dis)engagement. This study was done based on data collected from a course taught by the author since 2016.

1.7 Selection of Participants

Non-probability (convenience) sampling took place with regard to participants answering the questionnaires and participating in the focus group interview, whereby the selection of the sample was based on the availability of the participants (Cohen, Manion & Morrison, 2007). This research involved first year, first semester, CS learners completing a programming logic and design introductory course in the Information Technology (IT) faculty at a private higher education institution in Cape Town, South Africa. Due to ethical stipulations the researcher was not permitted to refer to the name, logo, brand, or any other identifiers of the institution in any way within questionnaires, interviews, and research reports.

1.8 Data Analysis

To assist with formal analysis, themes and concepts needed to be discovered that would result in overall explanations. Categories in themes and/or concepts needed to be compared to see if there were connections or disconnections so that a detailed, accurate theory would emerge for interpretation (Rubin & Rubin, 1995). Therefore, this study adopted the content data analysis method by Braun and Clarke (2006), which was used to provide guidance on thematic content analysis and assisted in contextualising the findings under relevant themes.

The data analysis was aided by making use of computer-aided software. Google Forms was used to administer Questionnaires A and B (see Appendices A and B) which were comprised of Likert scales and open and closed questions. Field notes were an additional form of data that included listening to and documenting learners' comments regarding the learning activities, answering learners' queries, grading learners' completed activities, and analysing data generated by the Learning Management System (LMS). This was analysed through an SR lens after the completion of the learning activities. The focus group interview consisted of questions with the aim of obtaining opinions on a deeper level and created a discussion space for group consensus or disagreement on pertinent issues. The focus groups also assisted to clarify meaning and provide a source of validation. Microsoft Excel was used for analysing the interview transcripts whereby each transcript was added to Microsoft Excel so that codes and themes could be generated. All participants were given aliases and de-identification took place. Ethical clearance was granted from the University of Cape Town – Humanities Ethics Board (see Appendix K) before any research was conducted with respondents. In addition, formal permission to conduct research was granted by the private higher education institution where the research was conducted.

1.9 Significance of this Study

This study contributes to the existing body of knowledge in four key ways. Firstly, the study demonstrates that understanding and analysing who the learners are and their *ultimate concerns* in life enables a deeper understanding of why learners choose to (dis)engage in a learning process. Secondly, the SR framework used in this study illustrates the interplay between culture, structure, and agency, which provides a means to highlight enablers and constraints that cause (dis)engagement. Thirdly, this study suggests that when certain learning design approaches are adopted, alongside the consideration of cultural and structural influences (enablers and constraints), an opportunity is provided for an agent to act and address their concerns. This contributes towards learner engagement, reducing dropout rates, and ultimately increasing the number of successful graduates in CSE programmes. Fourthly, the creation of a framework for research and design, with the main theme being a focus on ME – a framework that has the potential to be used as an analysis (research) tool by educators to determine why a learner is (dis)engaging in a learning process i.e., learning activity. Moreover, this is a framework that could be used to design and develop learning interventions that foster ME. By addressing the RQs, this study aims to contribute insights to the field of CSE, recognising the role of learner agency in the learning process and the opportunity it provides to enhance learner engagement.

1.10 Organisation of this Dissertation

Chapter 2 discusses the literature on the international and local (SA) perspectives of CSE, identifying barriers and challenges associated with learner engagement. Focus is on the relationship of these constraints and enablers through an SR lens and possible approaches to address these through learning activities.

Chapter 3 discusses the research design and methods, data collection, and methods of analysis used in this study. Ethical considerations, reasons for validity, and data management are provided. This chapter also describes the learning interventions, which are the design and development of each learning activity.

Chapter 4 presents the findings of this study with the chapter being divided into three parts. The first part focuses on who are the learners and what they care about, indicating enablers and constraints that contributed towards (dis)engagement. The second part, which occurred before the implementation of the learning activities, highlights what learners consider to be the most important aspects to support engagement. The third part, which occurred before the implementation of the learning activities, addresses the evaluation of the learning activities in terms of learner engagement.

Chapter 5 discusses the influence of intentionally designed learning activities on learner engagement. The influences and relationship between design approaches, learner engagement and agency in a Blended Learning (BL) course are discussed. In addition, SR is used to identify and explain the role of structural and cultural enablers and constraints

on learner engagement. Lastly, the Meaningful Engagement (ME) framework (developed by the researcher) is introduced as a framework that can be used by educators focusing on learner meaningful engagement.

Chapter 6 is a final response to the research objectives and questions. The chapter also provides suggestions for future research and recommendations for the design and development of learning activities that foster meaningful engagement.

Chapter 2: Literature Review

2.1 Introduction

Providing learners with the opportunity to study CS not only equips learners with the necessary skills to seek employment and adapt to the future, but also promotes logical thinking, problem-solving and algorithmic reasoning. Tucker (2003) defines Computer Science Education (CSE) as the study of computers and algorithmic processes, including their principles, their hardware and software designs, their implementation, and their impact on society. However, given these benefits such as developing problem-solving skills and developing a versatile skill set that will create career opportunities, the uptake of learners taking CS is low and the throughput rate is considerably lower (Havenga & Mentz, 2009; Vegas, Hansen & Fowler, 2021). This highlights that CS courses demand a high level of complex, conceptual, and technical knowledge and as a result many learners become disengaged and unmotivated in the subject area (Havenga & Mentz, 2009; Yadav, Gretter & Hambrusch, 2015). Furthermore, Gulatee and Combes (2006) indicate that a large percentage of learners battle to engage with CS resources in a blended learning (BL) environment and CS topics become challenging for learners studying in isolation. Feelings of stress, unease, and anxiety are emotions often experienced by learners studying CS and this contributes to disengagement.

This chapter sets out to explore the global state of CSE and the depth of the issues regarding (dis)engagement in the subject area. It then zooms in on the local South African issues. Moreover, a specific area of concern is highlighted: that learners struggle with the process of problem-solving and designing algorithms. Interventions that promote engagement are investigated, with reference to the role that digital learning activities play in engaging learners and how digital learning activities may be designed and developed using design approaches in a BL environment. Lastly, focus is placed on how to evaluate these digital learning activities through a Social Realism (SR) lens in the context of (dis)engagement.

The research for this thesis is based on a first year, first semester, tertiary course, that being algorithmic design. The course is introductory in nature and the content covered is similar to content covered in the CS subject at secondary level (Grades 10 to 12) and other tertiary institutions at first year level. For example, in the South African National Senior Certificate (NSC) Grades 10 to 12 IT subject, within the topic area of solutions development, learners are required to learn about algorithm design and development that facilitates problem solving. Learners are encouraged to tackle computational challenges through the identification and analysis of specific problem requirements, the creation of efficient algorithms, the translation of these into code, and the subsequent testing of the solution to ensure it fulfils the criteria. This is echoed in the South African Independent Examination Board (IEB) IT Grades 10 to 12 syllabus in which algorithmic problem-solving outcomes are promoted to develop learners' computational thinking practices. Similarly, in the course where this study was positioned, the learning outcomes are entrenched

in explaining terminology and concepts in programming, planning the data types and structures to be used in programming solutions, and solving programming problems using pseudocode and flowcharts. Pseudocode is an English-like representation of the logical steps needed to solve a problem, written in a way that resembles code but does not adhere to the syntax of any specific programming language (Farrell, 2018).

Examination of what is occurring at secondary and tertiary education levels places emphasis on the extent and depth of the issue at hand. The low throughput rate from secondary school to tertiary education and the considerably lower graduation rate speaks to the challenges experienced by CS learners, with disengagement an issue that has been identified (Vegas, Hansen & Fowler, 2021).

2.2 The Educational Challenge to Expand CSE (International and Local Perspectives)

2.2.1 The Global Landscape of CSE - International Perspectives

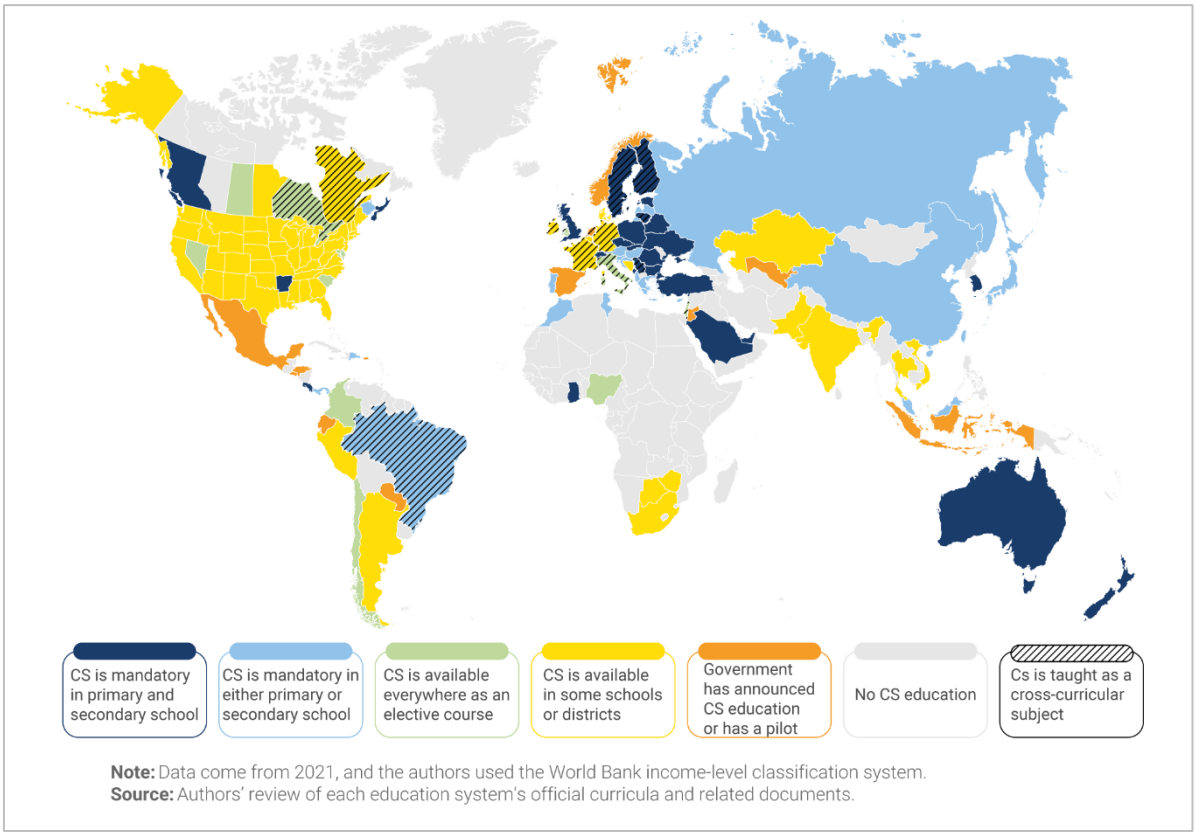


Figure 2.1: CSE Varies Across the World (Vegas, Hansen & Fowler, 2021)

In late 2021, the Brookings Institution published a report entitled *Building Skills for Life: How to Expand and Improve CSE Around the World*, which analysed global interventions by governments, and highlighted lessons learnt from the implementation of these initiatives (Vegas, Hansen & Fowler, 2021). In this report, Vegas, Hansen and Fowler (2021) indicated that there are commonly shared issues that governments experience (Figure 2.1). Issues that are seen as barriers and challenges to expand CSE globally are: (1) ensuring educators and learners have sufficient access

to devices and connectivity; (2) guaranteeing the availability of skilled teachers through teacher training and ongoing professional development programmes; (3) promoting learner engagement in CSE; and (4) creating curricula and fundamental skills, efficient learning techniques, and assessment of CS aptitude.

Computer Science Education in Ghana

With reference to Figure 2.1, most countries on the African continent have no CSE in primary and secondary schools. However, there is one country that stands out, Ghana. In Ghana CSE is mandatory in primary and secondary schools. Ghana has a rich and deep history of promoting CSE education, dating back to 1966, when upon returning from Princeton University Prof Francis Allotey created the first department of CS in Africa (Bainomugisha et al., 2023; Dunning, 2017). Since its introduction, CSE in Ghana has expanded incredibly, with a total of 41 tertiary institutions offering CS degree programmes (Bainomugisha et al., 2023). The structure of these degrees embody content such as data structures and algorithms that foster critical thinking and problem solving. The method of delivery at many of these universities include face-to-face and online lectures. This consists of practicals (laboratory sessions), case studies, projects, demonstrations, field trips and internships (Bainomugisha et al., 2023). Collaboration with industry is seen as being fundamental and companies such as Google Ghana and IBM Ghana provide opportunities for internships, with some of these companies setting up laboratories at universities and industry members giving talks and mentoring learners. In addition, the government of Ghana has invested heavily into the African Union agenda of doubling the 2013 GDP level by 2063 through increased computing penetration (Bainomugisha et al., 2023; Dunning, 2017).

2.2.2 Computer Science Education in South Africa

With respect to CSE globally, South Africa is far behind, emphasising the need for greater efforts and quality CSE (Figure 2.2). Examining the national education system reveals challenges, especially in CSE at secondary and tertiary levels. Figure 2.2 illustrates that in many countries, although Information Communication Technology (ICT) infrastructures at schools have improved, efforts to expand CS and ensure quality CSE are still needed (Vegas, Hansen & Fowler, 2021). With reference to the horizontal axis, it also highlights the lack of ICT infrastructure throughout the South African education system. The vertical axis indicates the degree to which the South African education system has not implemented the (non-infrastructure) capacity to expand CSE. The seven-point index measures policy actions to enhance CSE quality and access. The lines represent trajectories in these two dimensions for each country — each line records both a starting point (the bottom left point) and a point representing the present (the top right point). Each line in the figure represents one year, which relates to each education system's start date for implementing CSE (Vegas, Hansen & Fowler, 2021).

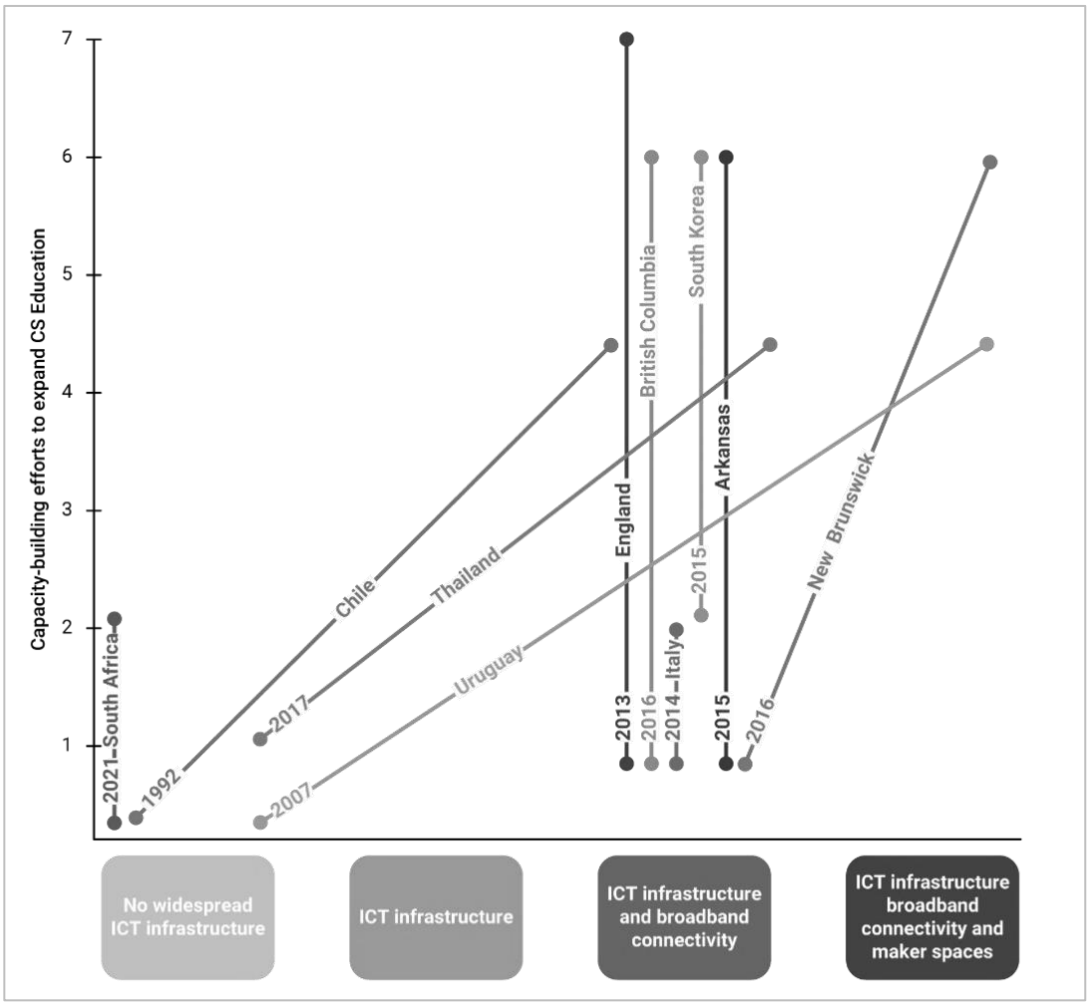


Figure 2.2: More Capacity is Needed to Ensure Quality CSE (Vegas, Hansen & Fowler, 2021)

At a School Level

In South African secondary schools, the subject is called Information Technology (IT), for the purpose of this thesis IT and CS are used interchangeably.

Within a South African context, Havenga and Mentz (2009) highlight concerns around the difficulty level of CS as a school subject in South Africa, indicating that learners generally find the subject different, and struggle to meet the practical and theoretical outcomes. Koorsse, Cilliers and Calitz (2015) state that South African CS learners often lack the necessary resources, indicating that CS textbooks are often out of date and lack the essential detail to engage learners. Yadav, Gretter and Hambrusch (2015) looked at the challenges that CS educators and learners face in United States of America. In this study educators mentioned that having appropriate content knowledge to effectively teach CS was a concern, furthermore, developing engaging materials for lessons was challenging. Sentance and Csizmadia (2017) conducted a study in the United Kingdom (UK) highlighting the most common challenges experienced by CS educators and learners, ranked in Table 2.1.

Table 2.1: Challenges: Most Commonly Occurring Themes (adapted from Sentance & Csizmadia, 2017)

Challenges	Teacher challenges	Number of cases with mentions
Challenges relating to teachers	Subject knowledge	97
	Differentiation	59
	Lack of time	53
	Approaches to teaching	52
	Dry (difficult to teach) topics	33
	Assessment	25
	Lack of support	20
Challenges relating to learners	Learners not understanding	76
	Learners and problem solving	59
	Learners resilience	46
	Learners not engaged	40
	Learners ability in Maths	26
	Learners literacy skills	14
	Learners not remembering	13
	Learners not practising	13
Challenges relating to resources	Technical problems	61
	Lack of resources	43
	Finding good quality resources	22

When analysing data in the South African Department of Basic Education (DBE) National Senior Certificate (NSC) Examination Report (DBE, 2021) there was a low percentage of 0.6% of learners who wrote the NSC IT papers in 2020. This low percentage is not unique to South Africa, as the California Schools Report in 2019 revealed that only 3% of learners took high school CS in 2017; however, the report indicated that this percentage had almost doubled in the past three years (Scott et al., 2019). This contrasts with the decline in the number of learners completing Grade 12 IT in SA, as indicated in Figure 2.3. It also speaks to the larger picture and the potential uptake of learners selecting CS at a tertiary level. In addition, this contextualises the difficulty learners experience with the subject resulting in increased dropout rates.

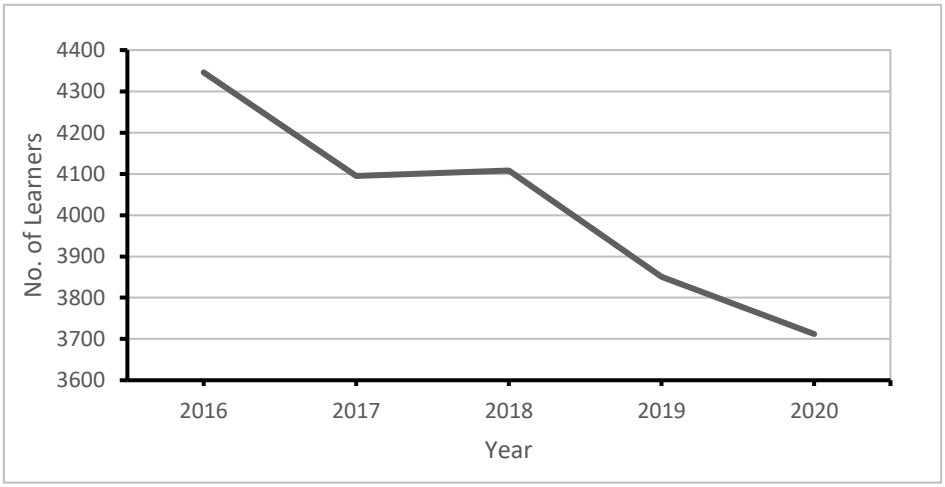


Figure 2.3: NSC Grade 12 IT Candidates

At a Tertiary Level

Similar issues experienced at a secondary school level are occurring at tertiary level, where CS learners also have difficulty passing programming-related courses. When attempting to determine a worldwide pass rate of introductory CS programming courses, drawing on insights from previous researchers, the pass rate is between 67-75% (Simon et al., 2019; Watson & Li, 2014). Watson and Li (2014) concluded that the failure rates in introductory programming courses were not concerningly high. However, Simon et al. (2019) argue that although at first glance this may appear to be the case, their research indicates that this percentage range sits at the low end of pass rates in introductory STEM courses. With specific focus on South African universities, the performance of CS learners at tertiary level has been of concern, with only a low increase in the number of undergraduate CS learners completing their degree (Mutanga, 2020).

The need to increase the percentage of tertiary CS graduates in South Africa is significant when looking at the job skills most in demand in 2023 and a spiralling unemployment rate. According to the Quarterly Labour Force Survey (QLFS) by Statistics South Africa (StatsSA; June, 2023), the overall unemployment rate in South Africa is 32.9%, with the unemployment rate among young people aged 25 to 34 years sitting at 40.7%. In relation, CareerJunction (2023) published its job skills index indicating the most in-demand jobs in South Africa, highlighting that the IT, business and management, and finance sectors are the most sought-after sectors, with the most hiring activity.

2.2.3 An Area of Concern in CSE: Algorithmic Design

When identifying the challenges that learners typically face in CS at tertiary level, many learners struggle with the process of designing algorithms (Gomes & Mendes, 2007; Jenkins, 2002; Medeiros et al., 2019; Thota, 2014). Gomes and Mendes (2007) argue that the most important issue related to learners dropping out and failure rates in introductory programming courses is learners' lack of problem-solving abilities. They stress that learners do not know how to program, because they do not know how to create algorithms, and this is mainly due to their lack of general problem-solving abilities. Furthermore, the main goal of an introductory programming course is to cultivate problem-solving skills through algorithmic thinking and fundamental programming concepts, rather than focusing on the syntax of a specific programming language (Medeiros et al., 2019; Santos, Gomes & Mendes, 2013; Thota, 2014; Yadin, 2011). Türker and Pala (2020) argue that an education in algorithms has a notable and beneficial impact on learners' performance in basic and advanced programming tasks, and learners' perceptions of self-efficacy in programming. Programming encompasses many distinct processes Figure 2.4, with the initial process proving to be the most challenging, that of understanding the problem and then designing a possible solution (algorithm) to address the problem is important, as the correct algorithm forms the foundation of any coding (Cheah, 2020). It is misleading to assume that a learner has mastered programming by merely dissecting and understanding programs

(Jenkins, 2002). Learners may exhibit signs of being able to code, however at a fundamental level, they fall short of designing algorithms that form the foundation for creative programming (Jenkins, 2002).

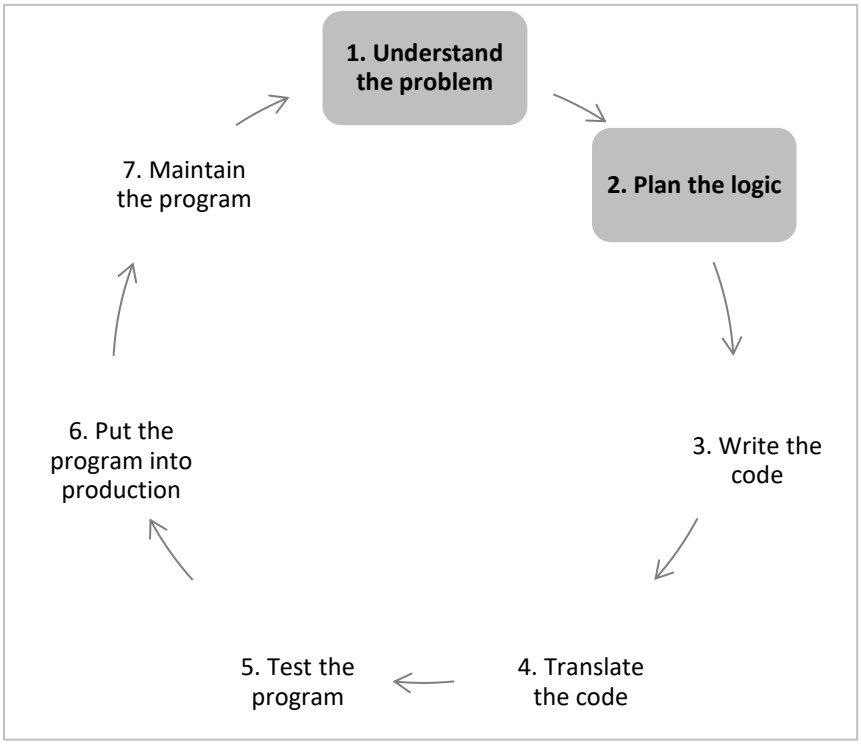


Figure 2.4: Stages in the Program Development Cycle (Farrell, 2018)

As mentioned, the theory of algorithms represents a basis for the solvability of problems and assists novice programmers with problem-solving strategies (Habiballa & Kmet, 2004; Koorsse, Cilliers & Calitz, 2015). The design of algorithms is therefore essential for engagement in the subject area, especially for mastering programming. Given the nature of the subject, it is pointless to base the teachings solely on memorisation as the subject in essence is entrenched in logical and algorithmical structure (Habiballa & Kmet, 2004). Furthermore, because these topics are difficult for learners to engage in, selecting the correct pedagogies is critical. Habiballa and Kmet (2004) suggest that when a learner is assisted to apply definitions, theorems, and proofs to concrete situations, only then does his/her knowledge deepen and become more durable. Koorsse, Cilliers and Calitz (2015) stress that by novice programmers designing non-code solutions to programming problems, will aid in breaking a problem into smaller, simpler parts making the problem easier to understand and solve. Furthermore, the planning of these solutions is often covered very briefly in the learning process by both the learner and the educator, yet this is critical in developing computational thinking practices.

This area of concern is not only occurring at tertiary level but also at secondary schools teaching algorithmic design as part of their CS curricula. Looking at the South African Grade 12 IEB IT practical and theoretical exam results, they reveal that the theoretical component of IT is problematic as it is challenging for learners. Figure 2.5 shines light on

the disparities between the practical versus theory Grade 12 IT exam results over an eight-year period (Independent Examinations Board [IEB], 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020).

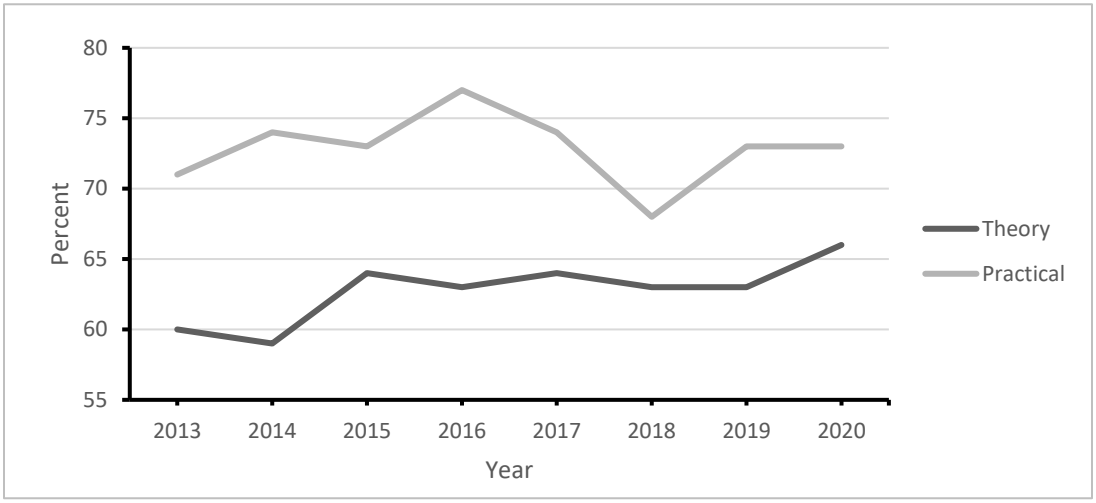


Figure 2.5: IEB Grade 12 CS Theory and Practical Exam Average Comparison

With reference to Figure 2.6, further analysis of the IEB Grade 12 IT theory exam over a three-year period indicates the difficulties learners experience with Question 7 (algorithmic design), which had the lowest average score of 55% (IEB, 2016, 2017, 2018). An analysis by Havenga and Mentz (2009) of the South African Grade 12 IT theory exam paper supports this, indicating that the question on algorithm and planning had the lowest average of all the theoretical questions, with an average of 46%.

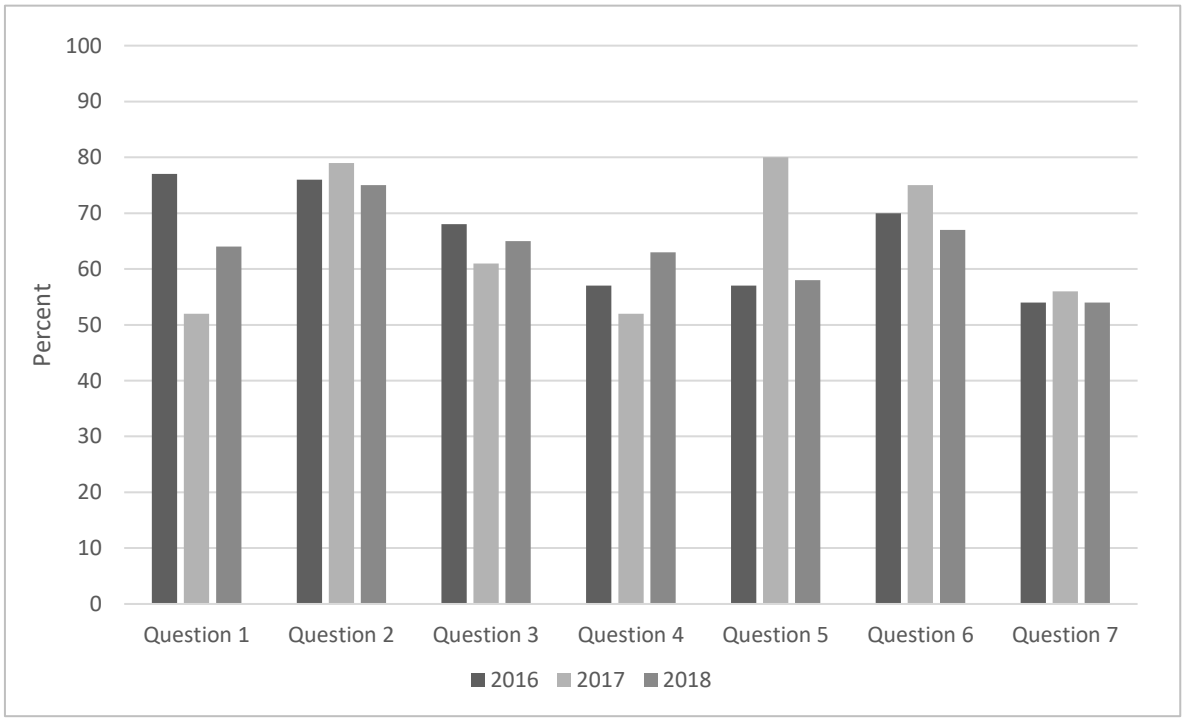


Figure 2.6: IEB Grade 12 CS Theory Exam Question Analysis

Given the challenging nature of this learning component within CSE, the research for this thesis is therefore based on an introductory course to programming logic and design. The purpose of the course is to provide learners with the foundation of logical program design, enabling learners to derive intuitive and innovative solutions to real-world problems following a hands-on approach. The course looks at algorithmic design such as flowcharts and pseudocode in the context of object-orientated programming so that learners may be equipped with necessary skills to express structured logic. Within these algorithms are sequence, selection, and looping structures, the elements that form a critical basis for understanding programming methodology and effective programming. In addition, the course takes on a language-independent approach to programming, introduces learners to universal programming concepts, and encourages logical thinking.

2.3. Fostering Engagement and Agency in Blended Learning Environments

2.3.1 Overview

There is a need for research to focus on how to teach CS effectively in an interactive engaging manner that develops lifelong skills (Bocconi et al., 2022). This view is supported by Jenkins (2002) who writes that programming-related courses at tertiary level need to be flexible and dynamic, allowing for learners to learn in various ways. This is supported by research indicating that a blended approach (an approach that utilises a variety of teaching methods, practical computerised lessons, and online/offline activities) to teaching CS is beneficial, as it provides the potential for adaptable learning experiences; for example facilitating collaboration beyond the classroom through online platforms (Ackovska et al., 2015; Curzon et al., 2009; Taub, Ben-Ari & Armoni, 2009; Vegas, Hansen & Fowler, 2021). Learner success in the CS subject area is strongly related to factors such as attitude, learners' expectations and the type of pedagogies implemented by the institution (Boyle, Carter & Clark, 2002). Kinnunen and Malmi (2006) support this, stressing that it is important to consider success factors when designing interventions. There is a need for educators and learning designers to design and develop learning interventions that embody the learner's interests and abilities (Chetty & van der Westhuizen, 2015; Hsu, Chang & Hung, 2018; Silva et al., 2019).

2.3.2 Pedagogical Strategies to Teach Algorithmic Design

Certain pedagogical strategies may be used to motivate and engage learners when teaching algorithms to CS learners and promoting computational thinking. These pedagogical approaches include: (1) problem-based learning (PBL) – learners identify a real problem that involves evaluating possible solutions and working in a team to solve it; (2) project-based learning (PjBL) – learners work for an extended period of time through the active exploration of real-world challenges; (3) collaborative learning; and (4) gamification which involves using competitive elements to increase the motivation of learners (Hsu, Chang & Hung, 2018; Silva et al, 2019). Chetty and van der Westhuizen (2015) who conducted research with CS programming learners within the context of a South African higher education institution, propose eight pedagogical design principles to facilitate engagement: (1) create a physical

learning environment that mirrors the real-world workplace; (2) offer authentic learning activities replicating real-world work scenarios with open-ended problems demanding prolonged effort for solution development; (3) enable collaborative learning activities; (4) offer learning resources that facilitate active engagement in constructing knowledge; (5) provide access to 'more knowledgeable others' to scaffold learning "on the edge of what they already know"; (6) support the development of metacognitive processes; (7) assess learning using a range of problems that exist in the real world; and (8) offer extra time for at-risk learners to engage with learning activities. These pedagogical strategies to teach algorithmic design were considered when designing and developing the learning activities for this study.

2.3.3 Meaningful Engagement

As previously mentioned, engaging learners in algorithmic design is a necessary key goal for CS educators, especially as disengagement can have a detrimental effect on the achievement of the learning outcomes (Ma et al., 2015). Krause (2005) defines learning engagement as the time, energy and resources learners devote to activities designed to enhance learning. Bond (2020:3) indicates that engagement is:

> *[T]he energy and effort that students employ within their learning community, observable via any number of behavioural, cognitive, or affective indicators across a continuum. It is shaped by a range of structural and internal influences, including the complex interplay of relationships, learning activities, and the learning environment. The more students are engaged and empowered within their learning community, the more likely they are to channel that energy back into their learning, leading to a range of short and long-term outcomes, that can likewise further fuel engagement.*

Using four categories, Handelsman et al. (2005) define engagement in further detail:

- Skills engagement (cognitive engagement and learning strategies); for example, keeping up with the activity and the effort involved.
- Emotional engagement (affective engagement and learning motivation); for example, applying the activity to their own lives.
- Participation/interaction engagement (behaviour engagement and active learning); for example, participating in group discussions.
- Performance engagement (assessment outcomes); for example, doing well in a test and achieving a good grade.

Wang et al. (2017) argue that engagement and disengagement should be considered as two separate constructs, a position supported in this research. Lenox, Jesse and Woratschek (2012) suggest several influential factors as to why learners (dis)engage at a tertiary level when studying CS. *Enablers* (engaging factors) that were identified include: (1) learners being exposed to CS in high school; (2) family members; (3) being exposed to technology at a young age; and (4) perceptions of career and employment opportunities in computing. In addition, having information resources at their disposal, such as the internet, enabled learners to conduct research and make informed decisions. The research conducted by Lenox, Jesse and Woratschek (2012) indicated that almost 30% of the respondents who were engaging in the course indicated that they had a family member who was working in a CS-related job. *Constraints* (disengaging factors) highlighted include: (1) teaching approaches to CS fall short and fail to inspire; (2) negative stereotypes based on an incorrect perception about what the study of CS entails and the type of careers that are available; and (3) a lack of opportunity to take CS at high school (Lenox, Jesse & Woratschek, 2012). Bond and Bergdahl (2022) add that although most learners desire engagement, they may divert their participation away from learning activities to focus on unrelated pursuits. This shift leads to disengagement from the learning process, potentially escalating into withdrawal. Neglecting this disengagement may result in a failure to identify crucial insights necessary to address the cause of disengagement (Bond and Bergdahl, 2022).

2.3.3.1 Indicators of Learner (Dis)Engagement

Indicators of (dis)engagement provide a means for the educator to recognise learner (dis)engagement related to the learning activities and determine if early intervention may assist in preventing further disengagement (Bond & Bergdahl, 2022; see Tables 2.2 and 2.3). In addition, Bond and Bergdahl (2022) highlight the role of social engagement (fourth column), stressing the importance of social knowledge-building. These indicators were considered when evaluating (dis)engagement with the learning activities for this study.

Table 2.2: Examples of Engagement Indicators (Bond & Bergdahl, 2022)

Participation/interaction engagement	Skills engagement	Emotional engagement	Social engagement
Effort	Critical thinking	Enthusiasm	Collaborating and interacting with peers
Study habits/homework completion	Self-regulation	Interest	Collaborating and interacting with teachers
Attending live lessons	Reflection	Satisfaction	Shared knowledge building
Assuming responsibility	Deep learning	Pride	Asking for help
Participation/ involvement	Focus/ concentration	Excitement	Caring for others

Table 2.3: Examples of Disengagement Indicators (Bond & Bergdahl, 2022)

Participation/interaction disengagement	Skills disengagement	Emotional disengagement	Social disengagement
Procrastination	Unwilling	Boredom	Feeling isolated
Absence	Apathy	Anger	Not feeling cared for
Giving up	Opposition/ rejection	Dislike	Withdrawing
Poor conduct	Avoidance	Disinterest	Social anxiety
Task incompletion	Unfocused/ inattentive	Frustration	Indifferent or negative to interaction

2.3.4 Blended Learning Pedagogies and Learner Engagement

Blended learning courses are a mix of traditional face-to-face (in-person) instruction and online learning (Graham, 2006). Dziuban et al. (2004) define blended learning as merging traditional classroom strengths with online, active learning opportunities. An example would be learners attending a class taught by an educator in a traditional classroom environment, whilst also completing online activities. Redmond et al. (2018) indicate that there is still much research to be done regarding engagement and BL, highlighting that a shift to BL requires adjustments to the teaching and learning practices traditionally associated with learning.

Blended learning environments offer 24/7 access to resources that can be updated and expanded in a fraction of the time compared to printed media. Furthermore, blended pedagogies offer the learner social interactions between learner-to-learner and learner-to-lecturer that may not be possible in an online mode. Blended pedagogies also have the potential to address the large learner-to-classroom ratio that several educational institutions grapple with. There are several BL pedagogies that may be represented in learning activities to promote engagement, such as: (1) blogging and/or commenting on course readings; (2) problem-based learning (PBL) that involves scaffolding; (3) flipped classroom activities; (4) brainstorming and mind mapping; and (5) game-based learning through gamification (Mirriahi et al., 2015).

These BL pedagogical approaches align with the pedagogical approaches suited for learning and teaching Algorithmic Design (Hsu, Chang & Hung, 2018; Silva et al., 2019). For example, in a BL environment, learners are given the flexibility to utilise a diverse set of learning resources when problem solving. In addition, BL can facilitate collaboration beyond the classroom through online platforms and communities. However, due to the difficult nature of the subject area, face-to-face classes are equally important as learners rely on immediate feedback, personal interaction, and hands-on activities which would otherwise be difficult to fully replicate in an online environment (Förster et al., 2021).

2.3.5 Key Technologies / Practices and Learner Engagement

Given the diverse set of resources (tools) a BL environment has the potential to offer, it was pertinent to look at possible key technologies and practices that will be useful when designing learning activities. Furthermore, several of these key technologies and practices align with the pedagogical strategies to teach Algorithmic Design. The concept of emerging technology (ET) in education refers to the use and integration of new and innovative technologies to enhance the learning experience, improve educational outcomes, and adapt to the evolving needs of learners and educators. Emerging technology in education is an extensive concept that can embody tools, concepts, and innovations used in various educational interventions to serve an array of purposes (Ng'ambi et al., 2012; Veletsianos, 2016). There are several innovative digital learning interventions such as: (1) gamification; (2) chatbots; (3) virtual reality (VR); (4) augmented reality (AR); (5) artificial intelligence (AI); and (6) online laboratories that are currently trending (Ferguson et al., 2019; Google & Canvas8, 2019; Kukulska-Hulme et al., 2020, 2021; Pelletier et al., 2022, 2023).

In the South African context, Ng'ambi et al. (2012) highlight that whilst key technologies and practices have the potential to transform learning, educators have not fully embraced the capabilities of these technologies and tend to use them in a rigid manner. For example, educators are 'pushing' content onto learners through mobile technology rather than 'pulling' learners in to engage with the content. Ultimately, it is the perceived practicality and cost of the new technology that will largely determine the learner's and educator's decision to fully make use of the technological tool for learning purposes (Oh & Hong, 2020).

The above-mentioned key technologies and practices were components for consideration when designing and developing the learning activities for this study.

2.4 Designing and Developing Learning Activities for Meaningful Engagement

In a book entitled *Make it Meaningful – Taking learning design from instructional to transformational*, Quinn (2022) discusses Learning Experience Design (LXD) and how to move educational theory into practice in the form of learning activities. When designing learning activities for meaningful engagement, it is critical to look at learners' interests and what they care about (Marsh, 2015; Quinn, 2022). The rationale is that if a learner is emotionally invested (before and during the implementation of a learning intervention) the probability of them being cognitively invested increases (Quinn, 2022).

Determining learners' interests and what they care about should involve divergent thinking (expanding possibilities; Marsh, 2015; Quinn, 2022). At the start of the design process this involves conducting research by gathering data, identifying and understanding user needs, as well as the user's "pain points". In the context of learner engagement, pain points are challenges such as lack of motivation, difficulty understanding material, or inadequate feedback that

prevent learners from fully engaging in the educational experience (Quinn, 2022). This assists in clearly defining the problem based on the user's insights and forms a design foundation based on empathy for the user. Thereafter, convergent thinking takes place by narrowing down and selecting the best solutions. This involves selecting specific problems or challenges to address. These problems or challenges come from data gained when determining the user's needs which involves prioritising and selecting the most relevant aspects of what users care about (Marsh, 2015; Quinn, 2022). This design approach was chosen for this study as it considers the divergent and convergent nature of design, which enables the designer to generate ideas before evaluating them too early (Quinn, 2022).

Thereafter, development starts to take place, Quinn (2022) uses a fishing metaphor of "Hook 'Em, Land 'Em" to represent four fundamental elements that need to be considered when designing and developing learning activities for ME. Firstly, there needs to be a theoretical understanding of how learners learn and how that aligns with engagement. Secondly, how to get learners to accept the experience (setting the hook). Thirdly, making sure learners achieve the learning outcomes (landing them). Fourthly, using tools (fishing lures, etc.) to assist in creating this experience.

Looking at the first element, Quinn (2022) indicates that for learning activities to be engaging there needs to be: (1) clear goals (outcomes); (2) an appropriate challenge; (3) practice within different contexts; (4) the activities need to be useful; (5) learners need to acknowledge the relevance of achieving the outcomes; (6) learners should be given freedom to explore possible solutions; (7) learners need to practice in the same ways that they will perform; (8) there should be appropriate feedback; and (9) there should be some form of maintaining attention, such as variability and unexpected occurrences. All these considerations aid in creating meaningful and engaging learning experiences.

For the second element, Quinn (2022) suggests that for learners to engage in a learning activity, there should be a design that goes beyond extrinsic motivation. Quinn (2022) argues that external motivation such as incentives and points, whilst important, are a rather weak sense of motivation. The aim is to move from "I **should** learn about programming logic" which is often associated with guilt to "I **need** to learn about programming logic" to ultimately "I **want** to learn about programming logic" which is related to passion. A learner should see the need for the learning experience, which involves the learner believing that: "I need to know this", "I don't know this already" and "this experience will change that" (Quinn, 2022). An example of this would be to make it personal, in the sense that you are addressing the learner's question of "What's in it for me?". By placing a learner in a challenging, real-world scenario, learners become viscerally aware of the learning content, for example in terms of money, or loss of life, or employment (Quinn, 2022). Interest can also manifest on a personal level, where learners exhibit a desire to engage in an activity for an extended duration. To cultivate situational interest, the learning activity should present challenges that captivate a learner's curiosity. Over time, this situational interest may evolve into individual interest

if learners perceive a connection between the learning activities and their own experiences and preferences (Panday-Shukla, 2023).

When considering the third element (landing them), making sure learners achieve the learning outcomes, Quinn (2022) suggests that the learning activity must have clear goals (outcomes) and that these activities need to be of interest to the learner. The learning activities should be at an appropriate level of challenge and there should be freedom granted to the learner to explore and be curious. Ideally, by using learning activities, learners should be able to practice in real-world contexts. The educator needs to respond in appropriate ways, in the form of guidance and adequate feedback that is timely and constructive to facilitate the learning process (Egbert et al., 2022). Furthermore, the educator should acknowledge the importance of emotions in relation to engagement.

The fourth element involves using learning design techniques to make an experience more engaging and getting the learners to invest emotionally in the process. Quinn (2022) suggests the following techniques to promote engagement in learning activities: (1) provide a story; (2) use exaggeration within a story; (3) make it social; (4) learning needs to be active; (5) provide ritual; and (6) bring in humour.

Bower's (2008) model for designing and developing digital learning activities was considered as a possibility, instead of adopting the design principles and practices discussed in this section. Bower (2008) offers a helpful framework for designing digital learning experiences by aligning the needs of the learning activity with the capabilities of the available technologies; designers are encouraged to assess whether the selected technology aligns with the predetermined cognitive demands of the learning activity. However, for this study it was important to gain a deeper understanding of what learners care about, not just what their pain points are but also what they enjoy and desire in the learning process. Furthermore, the design principles and practices indicated by Quinn (2022) have a particular focus on meaningful learner engagement in relation to designing digital learning activities. Therefore, design approaches discussed by Quinn (2022) were adopted for the design and development of the digital learning activities in this study (the design of the learning activities will be discussed in Chapter 3).

2.5 Selecting a Framework to Evaluate Learner Engagement in Online Digital Learning Activities

In this study Social Realism is used as a theoretical framework to unravel the complexities of meaningful learner engagement. Furthermore, SR assists in evaluating learner (dis)engagement within the context of learning activities. For this to be achieved, certain enablers (such as clear learning objectives, intrinsic motivations) and constraints (such as lack of engaging resources, disempowering social norms) are identified that influence learner (dis)engagement. An analytical dualism approach that separates culture, structure, and agency is followed by examining the interrelation between these three dimensions. This will allow for a more nuanced analysis of the social context in which this study is positioned.

2.5.1 Theoretical Framework

Social Realism is a theory that enables the analysis of societal change (Archer, 1995, 2003, 2006). The theory aims to identify the causal mechanisms to explain society. In SR, Archer (2003) argues for the importance of agency as a causal mechanism, for example, the learner's ability to take an active role in their own learning and make meaningful choices that influence their learning experience. In addition, Archer emphasises the role of internal conversations within individuals (Archer, 2003, 2006). These internal dialogues involve considering different courses of action, evaluating options, and making decisions based on personal concerns (values and goals; Archer, 1995, 2003, 2006). In this study, SR was used to explore and determine the influence of learners' agency and their internal conversations arising from their personal concerns that cause them to either engage or disengage in the learning process.

Culture, Structure and Agency in Relation to Learner Engagement

Personal identity is a matter of what we care about, our concerns, and that "our behaviour is regulated by hopes and fears" (Archer, 2006:269). It is the interaction between our concerns and environmental conditions that determine our emotional investment (Archer, 2006). Positive emotions encourage continued engagement whereas negative emotions result in a discontinuation of practice, that "our reactions to relevant events are emotionally transmuted by our ultimate concerns" (Archer, 2006:271). The environmental conditions are the structure (the context, e.g. institutional policies, a structured learning activity) and the cultural setting (a set of beliefs, e.g. cultural beliefs and norms about success and achievement) in which agents (individuals) find themselves. In this study agency was examined separately from culture and structure, and this analytical dualism approach helps to understand the relationship between these aspects of society. Archer (2007b) stresses that it is important to look at these separately before looking at how they are interrelated.

Archer (2003) indicates that when examining how structure influences agency, agents experience three stages in the mediatory process between structure and agency. The first stage is when agents develop 'concerns' - "those internal goods that they care most about" (Archer, 2007b:42; see Figure 2.7). The second stage is when those concerns result in elaborating a 'project'. Agents at this stage develop a course of action, within their current reality, that being physical well-being (nature), performative achievement related to work (practice) and achievement of self-worth (social). In the third phase, a course of actions (set of practices) is taken by the agents (Archer, 2007b). The successful transition from one phase to the next depends on the agent's ability to reflect on their situation and how they go about achieving projects. Archer (2006) argues that emotions are part of reality, and that our emotions are part of our response to the world.

Archer (2003, 2010) points out that agents choose what to invest in and this is based on what really matters to them. Agents have free will in this process, however there are degrees of freedom that are constrained by the social structure (Archer, 2003, 2010). Furthermore, Archer (2006) argues that self-worth is entrenched in desires and fears, and this determines what is important enough for an individual to be emotionally invested in something. For example, a learner who does not invest self-worth in school performance will not be downhearted by examination failure. In this light, through an SR lens, exploring learners' agency and their ultimate concerns sheds light on why learners may engage or disengage within a learning process. This supports why learners act in different ways (either engage or disengage) in the same structural and cultural context, highlighting the relationship between individuals and the social structures within which they operate.

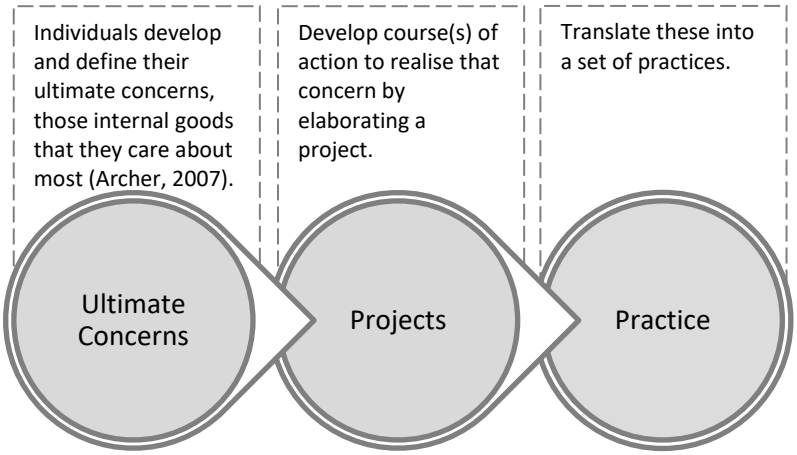


Figure 2.7: Ultimate Concerns of Agents (Archer, 2007a)

Enablers and Constraints

Social Realism also considers both enablers and constraints that influence how individuals exercise agency in their lives. *Enablers* are the resources, opportunities, and supportive factors that individuals may use to exercise agency. These enablers allow an individual to make meaningful decisions in pursuit of their desires, goals (Archer, 2003). Examples of enablers are: (1) a supportive family environment (which may be seen as a combination of structural and cultural influence); (2) educational opportunities (which are primarily a structural influence); and (3) mentorships (which may be seen as a cultural influence). *Constraints*, on the other hand, represent the barriers that individuals face in their pursuit of agency (Archer, 2003). These constraints may come from external factors, such as: (1) social norms (primarily considered cultural factors); (2) economic conditions (primarily structural factors); and (3) institutional rules (primarily structural factors), which may restrict an individual's actions. It is important to note that constraints and enablers can impede or facilitate courses of action. Thus, courses of action vary from agent to agent with regard to what is considered an enabler or a constraint. This helps to explain why, when different agents are confronted with the same conditions, they take different actions.

Archer notes that “constraints are confronted as situations that frustrate the achievement of desired outcomes” (2007a:215). Furthermore, life histories play a significant role in an individual's agency, as they provide insight into an individual's context such as social and economic background, education, and cultural background (Archer, 2003). Table 2.4 provides a summary of the identified enablers and constraints in this chapter.

Table 2.4: Why Learners (Dis)Engage – Enablers and Constraints

Enabler/ Constraint	No	Key Factor	Literature Reference	Related to Agency, Culture, or Structure
Enablers	1	**Perceptions of career and employment opportunities in computing**	(Lenox, Jesse & Woratschek, 2012).	**Agency/Culture** – individual or shared beliefs regarding career prospects in computing, which may influence learners' attitudes.
	2	**Being exposed to technology at a young age**	(Lenox, Jesse & Woratschek, 2012).	**Structure** – considered as part of the structural setup influencing learners' early experiences.
	3	**Clear learning objectives**	(Pelletier et al., 2023; Quinn, 2022).	**Structure** – a feature providing guidance and direction for learning.
	4	**Learner's interest in the subject area**	(Bocconi et al., 2022; Boyle, Carter & Clark, 2002; Kinnunen & Malmi, 2006).	**Agency** – the learner's personal motivation towards the subject, reflecting their agency.
	5	**Learning interventions that embody learner's interests and abilities**	(Bocconi et al. 2022; U.S. K-12 Computer Science Framework Steering Committee; 2016).	**Structure** – speaks to the design and implementation of educational interventions, representing an aspect of the structural framework.
	6	**Learners being exposed to CS in high school**	(Lenox, Jesse & Woratschek, 2012).	**Structure** – speaks to the educational system's setup, a structural influence on learners' educational experiences.
	7	**Appropriate feedback**	(Hsu, Chang & Hung, 2018; Quinn, 2022).	**Structure** – an educational structure, providing guidance and support to learners.
	8	**Real-world scenarios**	(Gulatee & Combes 2006; Howell et al., 2003; Quinn, 2022).	**Structure** – incorporating real-world contexts into learning activities, which can be considered part of the educational structure.
	9	**Problem based learning (PBL)**	(Hsu, Chang & Hung, 2018; Mirriahi et al., 2015; Quinn, 2022; Silva et al. 2019).	**Structure** – PBL is a specific instructional approach, representing a structured method of learning.
	10	**Project-Based Learning (PjBL)**	(Hsu, Chang & Hung, 2018; Silva et al., 2019).	**Structure** – PBL is a specific instructional approach, representing a structured method of learning.
	11	**Opportunities for collaboration**	(Sentance & Csizmadia, 2017; Silva et al., 2019).	**Structure** – collaborative activities within the educational structure.
	12	**Intrinsic motivation**	(Panday-Shukla, 2023; Richter 2021).	**Agency** – an individual's internal drive and motivation, reflecting their agency.
	13	**Life histories (i.e., supportive family environment)**	(Archer, 2003; Lenox, Jesse & Woratschek, 2012).	**Culture** – the cultural context of learners' life histories, which may influence their educational experiences.
	14	**Mentorships**	(Archer, 2003; Lenox, Jesse & Woratschek, 2012; Pelletier et al., 2023).	**Culture** – mentorships practices reflect cultural norms and values offering guidance and support.
	15	**Self-efficacy**	(Cukierman, 2015).	**Agency** – an individuals' beliefs in their own abilities to succeed, indicating their agency.
	16	**Accountability**	(Ariely & Wertenbroch, 2002; Tyner & Petrilli, 2018)	**Structure/Culture** – the institutional rules such as deadlines (consequences) that shape learners' behaviours. May also be seen as a cultural enabler, reflecting norms and expectations within the community.

Enabler/ Constraint	No	Key Factor	Literature Reference	Related to Agency, Culture, or Structure
Constraints	1	**Teaching approaches to CS fall short and fail to inspire**	(Lenox, Jesse & Woratschek, 2012).	**Structure** – instructional methods and approaches within the educational system.
	2	**A lack of opportunity to take CS at high school**	(Lenox, Jesse & Woratschek, 2012).	**Structure** – a structural constraint on learners' educational opportunities.
	3	**A lack of engaging (interactive) learning resources in CSE**	(Ackovska et al., 2015; Curzon et al., 2009; Koorsse, Cilliers & Calitz, 2015; Taub, Ben-Ari & Armoni, 2009; Vegas, Hansen & Fowler, 2021; Yadav, Gretter & Hambrusch, 2015).	**Structure** – the availability and design of educational resources within the structure.
	4	**Learners not being able to problem solve**	(Sentance & Csizmadia, 2017).	**Agency** – an individual's ability to engage in problem-solving, reflecting their agency.
	5	**Learners lacking resilience**	(Sentance & Csizmadia, 2017).	**Agency** – resilience being an individual's trait that enables the individual to overcome challenges, indicating agency.
	6	**Educator lacking in subject knowledge**	(Sentance & Csizmadia, 2017; Yadav, Gretter and Hambrusch; 2015).	**Structure** – relates to the competence of educators within the educational system.
	7	**Learner's ability/skill set (i.e., ability in maths)**	(Sentance & Csizmadia, 2017).	**Agency** – an individual's own abilities and skills, indicating agency.
	8	**Disempowering social norms**	(Archer, 2003).	**Culture** – cultural norms and values that may hinder individuals' agency.
	9	**Economic hardship**	(Archer, 2003).	**Structure** – economic factors represent structural constraints on individuals' opportunities.
	10	**Detrimental institutional rules**	(Archer, 2003).	**Structure** – institutional rules are part of the structural makeup of the educational institution.

2.5.2 Research Overview with Concepts / Theory

Given the complex nature of why learners engage or disengage from the learning process, Figure 2.8 below provides an overview of the concepts and theory used in this study. At the heart of this study is meaningful engagement (ME), the time and energy a learner devotes to a learning activity by using technologies to assist when problem-solving in a BL environment. The learning activities aim to encourage ME, not just engagement on a superficial level, but engagement that fosters the internal intrinsic motivation of "want" to learn.

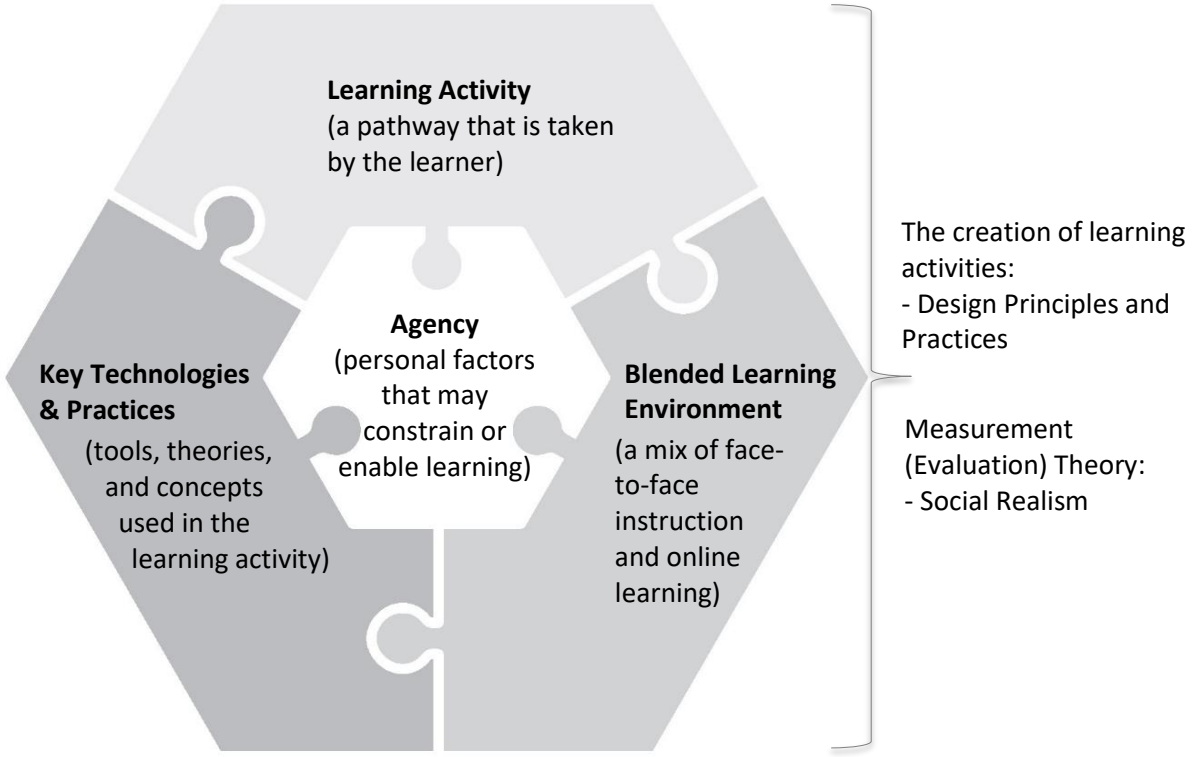


Figure 2.8: Towards Meaningful Engagement (ME) – Concepts/Theory used in this Study

2.6 Summary

The review of the existing literature identified an area of concern within the study of CS, which is that learners struggle with the process of designing algorithms. Insights into pedagogical design approaches, agency, and BL environments were highlighted with the aim to develop engaging learning activities. Moreover, within the context of this study, common key enablers and constraints as to why learners engage or disengage from the learning process were identified. To promote these identified enablers (engaging key factors) and to mitigate against these constraints (disengaging key factors), design approaches are used in the creation of the learning activities. Furthermore, SR was used to explore and evaluate the nuances that exist within these enablers and constraints.

Chapter 3: Research Design and Methods

3.1 Introduction

This chapter outlines the research orientation, type of research, and research approach used in this study. This was an empirical study in which a systematic approach was used to design the study and collect data. Thus, this chapter will be structured in chronological order including all the integrated steps that took place.

The Research Questions (RQs) are:

Primary RQ

RQ 1: What is the relationship between design approaches, meaningful engagement, and agency in a blended learning Computer Science theory course?

Secondary RQs

RQ 2: What, if any, influence did the use of design approaches have on meaningful engagement?

RQ 3: What experiences and features of the learning activities do learners find engaging or disengaging?

RQ 4: What are the structural and cultural enablers and constraints?

RQ 5: To what extent, if any, did learner agency influence meaningful engagement in this course?

3.2 Research Design

3.2.1 Mixed Methods Approach

At the core of a mixed methods study is an approach that embodies quantitative and qualitative methods of data collection and analysis (Creswell et al., 2003). When combining these two research methods a more nuanced comprehension of a particular research problem may evolve (Clark & Ivankova, 2015). Although a mixed methods approach can be more complex and requires more time for data collection, analysis, and interpretation, this approach provides a form of data triangulation which increases the validity of the findings. By comparing findings from different techniques, for example utilising a convergent design in which quantitative and qualitative data are collected concurrently, analysed separately, but then compared together, the researcher can confirm their research outcomes (Zohrabi, 2013). Given these benefits, this research study adopted a mixed methods approach consisting of questionnaires, field notes, and a focus group interview.

3.3 Research Context

This research was conducted during the first semester of 2022 at a private higher education institution in Cape Town. This research was conducted in the field and involved first year, first semester CS learners completing a Programming Logic and Design introductory course in the Information Technology faculty. The blended learning course aimed to provide learners with essential problem-solving skills and algorithmic thinking. The course consisted

of 70% face-to-face lectures and 30% online activities in the form of asynchronous and synchronous online learning activities.

3.4 Sampling and Participants

The CS course, which was divided into two classes, consisted of 67 learners in total. Learners from different racial, social, and geographic backgrounds responded to the questionnaires and participated in the focus group interview. The intention was to obtain data from all 67 learners, however only 16 learners responded to Questionnaire A and 16 learners to Questionnaire B. For the focus group interview, seven learners from the 16 who completed the survey took part. Therefore, non-probability (convenience) sampling took place regarding participants answering the questionnaires and participating in the focus group interview.

3.5 Data Collection

Two questionnaires, field notes and a focus group interview were used to collect data for this research. Figure 3.1 provides a graphical view of the data collection tools used at each stage of the process.

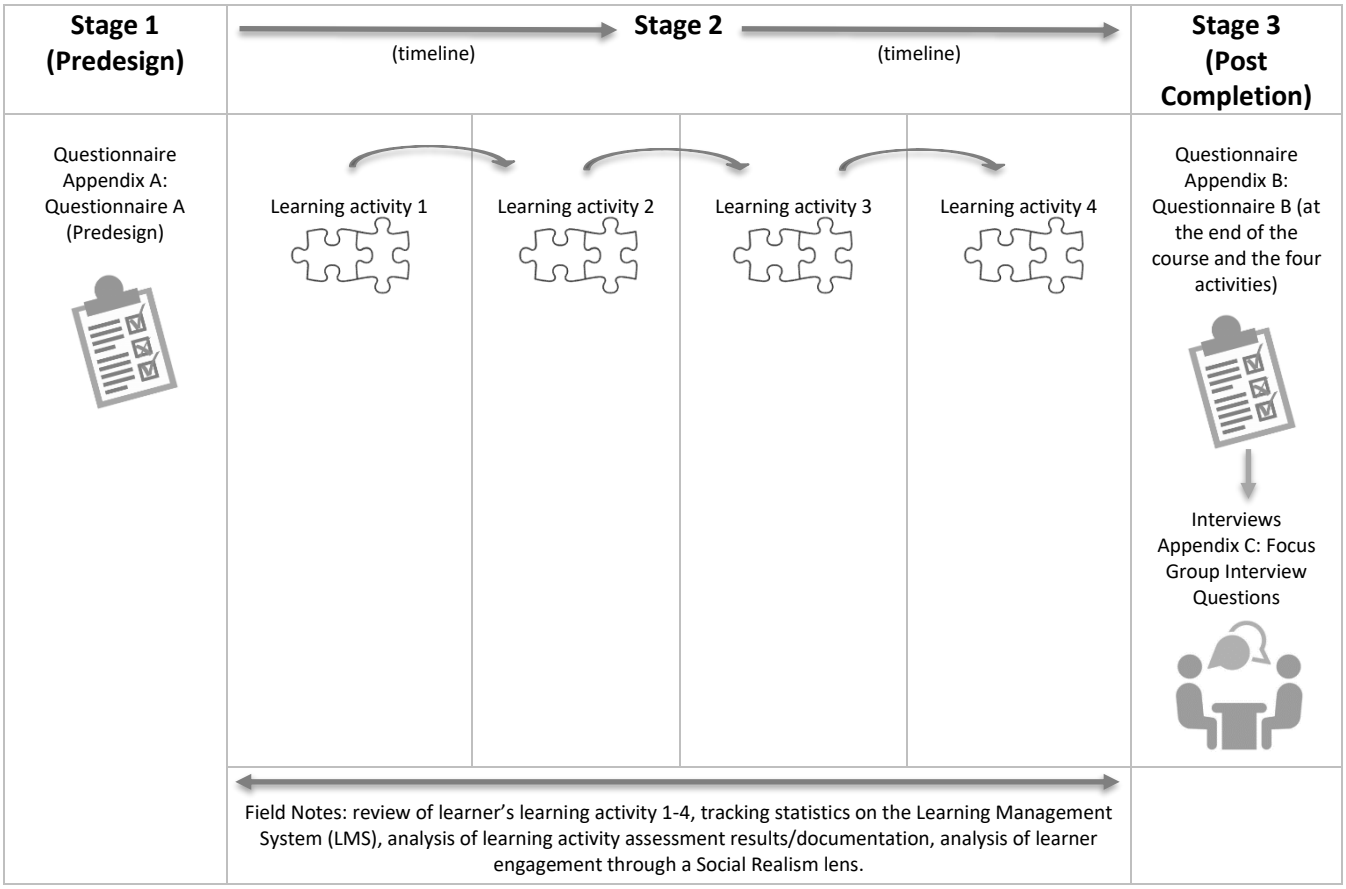


Figure 3.1: Graphical View of Different Stages that form the Data Collection Plan

3.5.1 Questionnaires

Self-report questionnaires are commonly used by researchers to assess engagement as a means of directly and reliably determining learners' views of a learning activity (Jones, 2020). Furthermore, online questionnaires, such as Google Forms, give researchers the ability to efficiently administer questionnaires online and at a distance. Scales used in the questionnaire provide an extent to which a learning activity was effective, creating an opportunity for in-depth analysis. Moreover, researchers can check the reliability and validity of a scale by comparing the scores with other measurements such as behaviour measurements (through statistical tracking on the LMS). Questionnaires also lend themselves to open-ended qualitative questions, providing the opportunity and flexibility for learners to express their perceptions regarding a learning activity in an open manner (Jones, 2020).

At the predesign stage (Stage 1), an online questionnaire using Google Forms (Questionnaire A; see Appendix A) was disseminated to each learner via email with a link to the Google Form. Insights gained from responses to Questionnaire A assisted in creating empathy for the user and aided in identifying nuances that informed elements to consider when designing and developing the four learning activities. Questionnaire A consisted of qualitative and quantitative questions, including biographical, structured and unstructured questions, and questions that used a semantic differential scale.

A measurement framework questionnaire (see Appendix B) consisting of the Online Student Engagement Scale (OSE) and additional learning activity engagement questions developed by the author, was used. The OSE Scale by Dixson (2010), which is based on Handelsman, et al.'s (2005) Student Course Engagement Questionnaire (SCEQ), is a self-reporting questionnaire that makes use of a scale to determine engagement. The OSE is a validated, useful tool that provides feedback to designers on learners' experiences after a learning activity (Dixson, 2010, 2015). Limitations regarding self-reported responses are present if a learner's responses do not match their behaviour and true views, and if the time frame of the administered questionnaire is greatly detached from when the learning activity took place (Jones, 2020). Therefore, a multifaceted approach was taken in this study, including the theory of Social Realism (SR). Social Realism was used as a theoretical framework to investigate how learners actively engage with and respond to their educational environment, in this case, four learning activities.

3.5.2 Field Notes

To determine the effectiveness of each learning activity once completed, in Stage 2 data was collected in the form of field notes. This involved listening to learners' comments regarding the learning activities, answering learners' queries, grading learners' completed activities, and analysing data generated by the LMS (for example, quantifying how many learners completed each learning activity). In addition, participants' engagement was analysed through an SR lens during and directly after the completion of each learning activity. Mulhall (2003) indicates that a major

rationale for using observational methods is to determine if what participants say they are doing, is in fact what they are doing. This allows the researcher to provide context and highlights interactions that capture the whole picture.

3.5.3 Facilitated Focus Group

A one-hour face-to-face focus group interview was conducted at the end of the course. A group of seven participants, consisting of six males and one female, took part in the focus group interview. The focus group was aimed at exploring participants' views of the activities, the course, and the role of agency within the context of engagement and/or disengagement in more depth. The researcher placed emphasis on creating a comfortable and safe space for participants to engage with the questions (see Appendix C). Discussions were initiated by the researcher, however, there were also unstructured discussions which highlighted new topics and enabled probing questions to be asked to determine relationships between design approaches, agency, and engagement. Edley and Litosseliti (2010) support this, indicating that focus group interviews allow for the effectiveness and impact of the learning activities to be determined by allowing for multiple views on a specific topic to be expressed and encourage participants to draw on personal experience.

3.6 Intervention Descriptions: The Four Learning Activities

The research conducted in the literature review, the findings from Questionnaire A (predesign), and the field notes gathered from this study resulted in the design and implementation of the four learning activities. A summary of the four learning activities is provided below, however a more detailed explanation with the design approaches is provided in Appendix D. In **Activity 1** learners needed to design and develop certain types of algorithms based on a real-world problem they had identified. Learners were given the freedom to decide if they wished to work in a group or alone. In **Activity 2** a web-based gamified quiz was designed in Quizizz for learners to engage with. Gamification uses game-design elements like points, badges, leaderboards, challenges, and rewards in non-game contexts to enhance user engagement, making tasks more enjoyable and goal-oriented (Deterding et al., 2011). **Activity 3** involved learners interacting and contributing to the discussion board on the LMS. The focus of this learning activity was for learners to choose and implement selection structures in an algorithm based on a real-world scenario. In **Activity 4** learners needed to research arrays and then complete a test, which was placed on the LMS. Arrays are used to store multiple values of the same type in a single, manageable structure, allowing for efficient data manipulation and easy access to elements via indexing (Farrell, 2018). Learners needed to summarise a chapter, watch videos, and answer some questions prior to completing the test. These activities were intended to encourage meaningful engagement (ME), not just engagement on a superficial level, but engagement that fostered the internal intrinsic motivation of "wanting" to learn.

In addition, Bloom's (1956) revised taxonomy by Anderson & Krathwohl (2000; Figure 3.2) was used to assist in maintaining a focus on the learning outcomes. The four activities aimed on achieving Bloom's higher order thinking skills (HOTS) To effectively achieve HOTS, the other levels of cognition needed to be achieved at varied depths. In other words, to reach the learning outcomes learners needed to have attained lower order thinking skills (LOTS) such as: (1) remember; (2) understand; and (3) apply; before progressing onto HOTS such as (4) analyse; (5); evaluate; and (6) create.

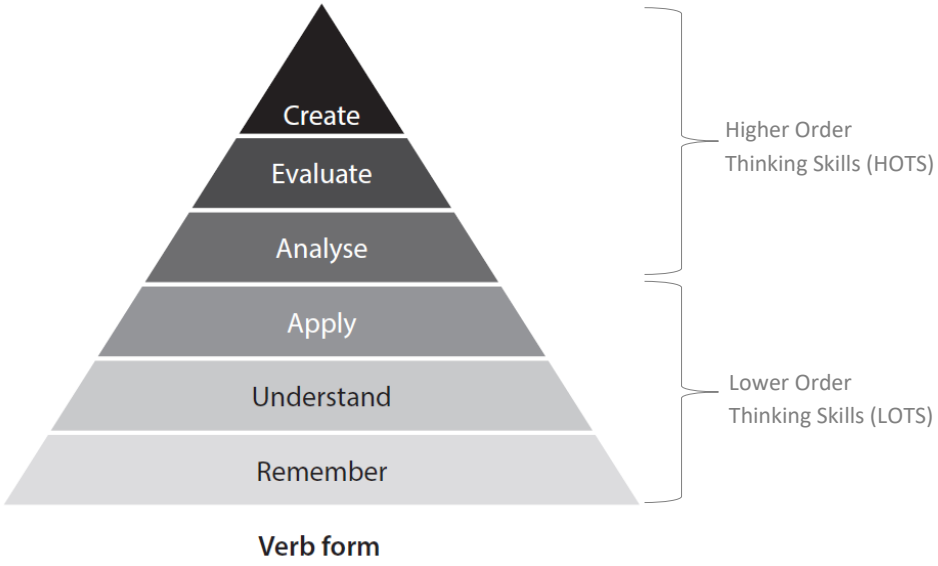


Figure 3.2: Bloom's (1956) Revised Taxonomy (Anderson & Krathwohl, 2000)

An overview of the learning activities in relation to Bloom's (revised) Cognitive Outcomes is indicated in Appendix E. The tools used in each learning activity are indicated in Appendix F.

3.7 Procedure

The following stages were taken to gain the necessary data:

Stage 1: Administrating the predesign Questionnaire (see Appendix A)

Stage 2: Whilst learners completed the learning activities, data was collected in the form of field notes.

Stage 3: Once the learners had completed the learning activities, the overall effectiveness of the learning activities was evaluated by comparing and contrasting participants' engagement in relation to the learning activities and tools used. The data collected and analysed at this stage was carried out through mixed methods consisting of:

- A Measurement Framework Questionnaire consisting of the Online Learner Engagement Scale (OSE) and learning activity engagement questions (see Appendix B). Google Forms was used to administer the questionnaire and a link was emailed to learners.

- An analysis of formative assessment results/documentation gained from learners engaging with the learning activities.
- A focus group interview that took place after the completion of the four learning activities (see Appendix C for the focus group interview questions).

Respondents were observed, questioned, tested, and interviewed throughout the four learning activities over a four-month period as represented in Figure 3.3.

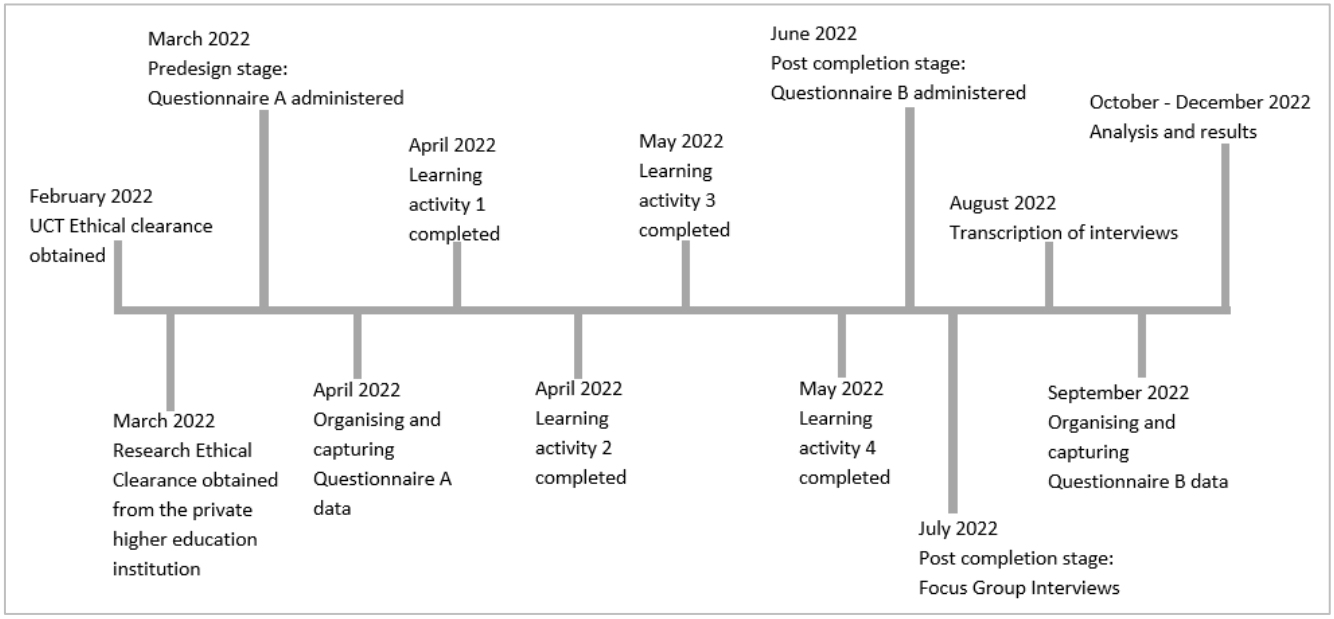


Figure 3.3: Data Collection and Analysis Timeline

3.8 Data Analysis

For formal analysis to be effective, categories in themes and/or concepts need to be compared to see if there are connections or disconnections, so that a detailed, accurate theory may emerge for interpretation (Rubin & Rubin, 1995). The 'content data analysis' method by Braun and Clarke (2006) was used which provided guidance on thematic content analysis. Krippendorff (2004) defines content analysis as a research technique for making valid conclusions from texts that can be applied to their respective contexts of use. This data analysis method can be used with qualitative and/or quantitative types of analysis to provide a detailed analysis of the data (Maxwell, 2008; Terry et al., 2017; White & Marsh, 2006). A benefit of using Braun and Clarke's (2006) thematic content analysis is its flexibility, allowing for the analyses to be used within other frameworks. In addition, this analysis approach was adopted as the methods are entrenched in understanding opinions and perceptions of participants.

Braun and Clarke (2006) promote six phases for identifying themes, a summary of these phases and how they were used in this research is indicated below:

Phase 1: Becoming Familiar with the Data

This involved the researcher engaging with, and immersing themselves in the data by reading through it numerous times (Terry et al., 2017). Furthermore, initial note taking at this phase is essential (Braun & Clarke, 2006).

Phase 2: Coding the Data

Coding involved recognising and creating codes based on data that stand out to the researcher as significant and addressing specific parts of the research question. For this research, the data were coded manually in Microsoft Word, using the colour and highlighter tools to indicate pertinent parts (see Appendix G). In addition, codes and direct comments related to each research question were placed in separate columns within a table (see Appendix H). Notes and comments of interest were made in the last column.

Phase 3: Discovering Themes within the Data

After reviewing the codes, they were merged and grouped together into broader themes (i.e., a main organising idea that was common across the codes). Therefore, codes which contained common ideas that were reoccurring across the questionnaires and the focus group were grouped together and represented as a theme. Graphical mapping was used (see Appendix I) as it is helpful in establishing clarity (Braun & Clarke, 2006).

Phase 4: Studying the Themes

The themes created in Phase 3 were studied and further refined to confirm that they adequately represent the grouped coded data (Braun & Clarke, 2006; Terry et al., 2017). For this research, this involved making sure no themes overlapped and that there was a sufficient data set to uphold the particular themes. This also involved the removal of certain themes that were not sufficiently supported by the data set. To ensure themes accurately portrayed the data set, data from the questionnaires and focus group were re-read.

Phase 5: Labelling Themes

Labelling involved determining the relationship between the themes and the research questions (RQs). Braun and Clarke (2006) highlight that a relevant theme is one that has a singular focus, does not overlap with other themes, and directly addresses your RQs. For this research, a short summary accompanied each theme that assisted in clarifying the link between the theme and the RQs. The relevant themes that emerged are discussed in Chapter 5.

Phase 6: Producing the Report

This last phase involves the complete set of themes and forms an intricate part in the Discussions section of the research (Braun & Clarke, 2006). This can be found in Chapter 5, where the data under the relevant themes is linked to the existing literature and theoretical framework to answer the RQs (Terry et al., 2017).

To assist with the above process, quantitative data (from both questionnaires) was scored and recorded in Microsoft Excel. These responses were also summarised (tallied) and graphically represented in graphs using Microsoft Excel. The focus group interview included qualitative questions (see Appendix C). Responses from the focus group were audio-recorded and transcribed verbatim with the permission of each participant. Microsoft Word was used for analysing the interview transcript, and codes and themes were assigned (see an example of this in Appendices G and H). All participants were given aliases and de-identification took place. Theme maps, representing common themes, were created by the researcher in Microsoft Word. This formed part of Phase 6 of the data analysis process. In total, four theme maps were developed: (1) Predesign stage: Questionnaire A; (2) Post completion stage: Questionnaire B; (3) Post completion stage: Focus group interview; and (4) Overall Themes (from the questionnaires, focus group and observations).

As mentioned in Chapter 2, SR was used as a theoretical framework within this study. Therefore, the principles of SR were applied during the analysis phase which involved looking for patterns and themes that emerged from the data related to: (1) learner agency - internal dialogues arising from personal concerns that cause a certain action, for example an action to engage or disengage in a learning activity; (2) enablers and constraints that influence how learners exercise agency in their lives; and (3) the structure (the context) and the cultural setting (set of beliefs) in which agents (individuals) find themselves.

3.9 Ethical Considerations

Before any research was conducted involving respondents, ethical clearance was granted from the University of Cape Town – Humanities Ethics Board (see Appendix K). Formal permission to conduct the research was granted by the private higher education institution where the study took place. All respondents provided consent by reading through the Request Letter to Conduct Research (Appendix L) and completing the Consent Form (see Appendix K) before any questionnaires and the interview were administered. Compliance with the National Government Legislation (i.e., the South African Protection of Personal Information Act [POPIA]) was adhered to, as discussed in the Data Management Plan (DMP; see Appendix M).

Respondents participated on a voluntary basis and were not under any physical, psychological, legal, or social risk during the research process. Clear verbal explanations were given at the start of the research as to the nature of what was expected of the participants, and they were informed that if they chose to withdraw at any time during

the research they could do so without negative consequences. The language used in the questionnaires and interview was simplistic in nature and further assistance was offered to learners who struggled to understand what was being asked. Participants needed to complete and sign a Consent Form (see Appendix J) before research was conducted. The Consent Form confirmed the confidentiality of participants in the research process. Furthermore, this was clearly indicated on the questionnaires, and at the start of the interview, to reassure participants that their data would only be used for this research and in no other way. No names or identifying information of participants was used within the research. In addition, no photographs of were taken of the participants.

Heidegger (1945/2002) defines an *aporia* as an internal contradiction, a perplexity, and an uncertainty about where to go next driven by a desire to progress. As I lectured the learners I was researching, I was aware of the ethical dynamics that may exist because of power relationships. Williams (2009) looks at ethical aporia in this type of setting and suggests several aporia to consider. An aporia relevant to this research is "guilty knowledge", in this case knowledge about a learner that may cause harm to that learner. Learners that I was lecturing may have felt the need to provide certain answers in fear of prejudice from myself, their lecturer. I attempted to guard against this subjectivity by providing, in the Request Letter to Conduct Research (see Appendix L) and the Consent Form (see Appendix J), a detailed account of the nature of the research, stating that respondents will by no means be subjected to prejudice because of their answers.

3.10 Validity

Validity is the consideration of multiple interpretations of results and how the data collected may support or challenge the researcher's conclusions The threat of misinterpretations may manifest itself in respondents not providing their actual views, or data having been side-lined because it does not fit in with the researcher's interpretations (Maxwell, 2008, 2013). Maxwell (2013) indicates that there are two main types of threats to validity: researcher subjectivity and the influence the researcher has on the individuals he/she is researching. Hammersley and Atkinson (1995) stress the importance of contextualising this influence and using it productively rather than trying to eliminate it. Building on this notion, Maxwell (2013) suggests procedures that will assist in giving credibility to conclusions, highlighting that the researcher is positioned in the setting studied, and that detailed continuous field notes, interviews, and administered questionnaires will contribute to the authenticity of the findings and theories being formed. Moreover, the collection of "rich data" through intensive questionnaires, interviews and field notes will provide a detailed overall picture. The mixed methods research approach in this research aided in the collection of rich data and provided a useful mechanism to address validity threats.

Although this research was conducted at a single site, there were opportunities to make comparisons across individual data. The triangulation in this research involved collecting data from a diverse range of individuals using

various methods. This mixed methods approach comprised of qualitative and quantitative questionnaires, field notes, a focus group interview, documentation analysis, learner's learning activity tracking statistics, and analysis of learner engagement through an SR lens, allowed for a better and more detailed understanding of the results.

With regard to agency, Cox (2016) highlighted that one problem with asking respondents to express their internal conversations, is that they themselves struggle to understand their own internal conversations. This might result in double interpretation occurring and therefore it is important to also investigate internal conversations that are considered "imperfectly successful communication" (Archer, 2003:155). Due to this, the mixed methods approach contributed to counterbalancing any discrepancies that may occur in a single research method, and assisted in reinforcing the validity of the research.

3.11 Management of Research Data

The handling of data has become increasingly more important to protect research information through responsible data management instruments. Hertzog et al. (2021) indicate that in order to adhere meaningfully to the principal aims of the South African Protection of Personal Information Act No. 4 of 2013 (POPIA), researchers need to understand the implications of this legislation on research practices. Hertzog et al. (2021) discuss several much-needed elements that need to be used to minimise the risk brought on by datafication in research and to be compliant with the POPIA. The DMP (see Appendix M), developed by the researcher, incorporated these elements, and was utilised in making decisions about how data was handled throughout the data life cycle, that is the collection, processing, analysing, preserving, sharing, and archiving of data.

Chapter 4: Findings

4.1 Introduction

Several identified themes emerged throughout the study before, during, and after the implementation of the learning activities. This chapter is structured into three parts: Part 1 sets out to understand who the learners are, their experiences and their behaviours. This section also investigates what learners care about and what their concerns are. Part 2 examines learners' understanding of engagement, and factors they consider to be important when engaging with learning activities and a course. This is the pre-implementation stage, and took place before the implementation of the learning activities and at the start of the course. Lastly, Part 3 delves into the learners' thoughts on the activities and the course. The focus is on the learners' views, particularly how their engagement increased and/or decreased. This section is the post-implementation stage, as it took place after the implementation of the learning activities and towards the end of the course. Therefore, the findings in this part are related to the learner's evaluation of the implemented learning activities and the course within the context of engagement.

4.2 Part 1: Who are the Learners and What Do They Care About?

Part 1 provides an overview of the participants, their experiences (aspects of their life histories) and life concerns. The focus is on investigating constraints, factors that hinder a learner's ability to take action, as well as enablers, which are factors that facilitate a learner's ability to take action.

4.2.1 Demographics

To deidentify the participants of this study, names and surnames were removed, and they are simply referred to as Participant 1, Participant 2 and so forth. The age range of the participants ranged from 18 to 21 years. Other demographics, such as gender, home language etc., have not been included, as this was not the focus of the investigation, nor did the additional demographic results have any impact on the nature of this study.

4.2.2 Enablers that Contribute to Engagement

4.2.2.1 Digital Learning Experience and Technological Exposure

In the predesign stage, the consideration of learners' levels of familiarity and comfort was essential before designing the learning activities, which also contributed towards empathising with learners. When determining a learner's digital learning experience, over 80% of participants indicated that their previous digital learning experiences had been entrenched in paced activities that provided clear instructions and used a level of language that was easy for them to follow. However, only 63% of participants indicated that in the past they were provided with activities which encouraged them to engage critically with the content. Even fewer participants, 50%, indicated that they were required to complete and submit learning activities (Figure 4.1).

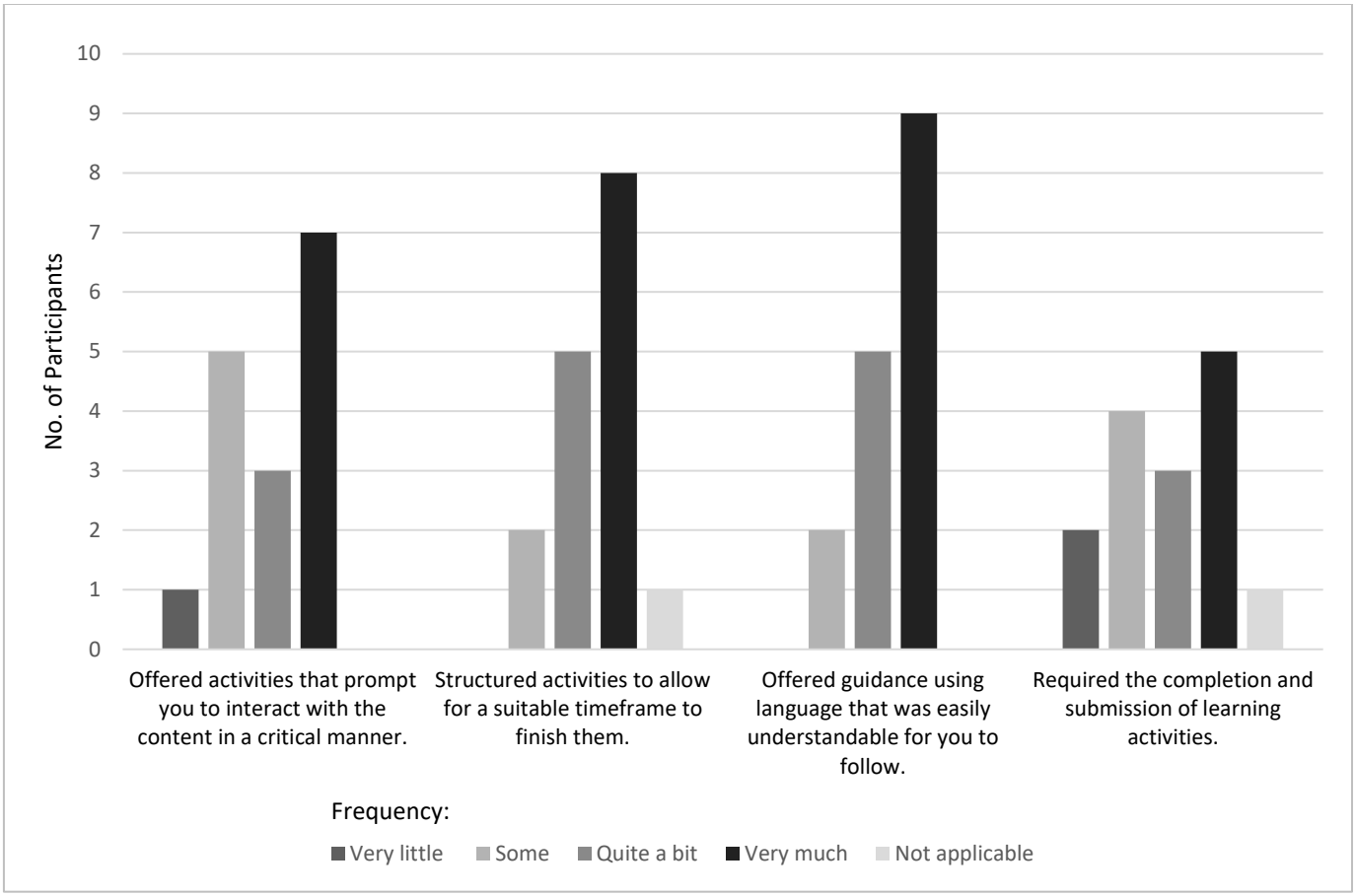


Figure 4.1: Extent of Digital Learning Experience

During the predesign stage, most participants indicated that they frequently make use of online tools (e.g., email, applications, etc.) and the school or college's learning platform to complete activities (Figure 4.2). This is important to note as assessing this exposure assists in designing blended learning activities that are more personalised. Furthermore, it may identify areas where support is needed for learners who have not been exposed to certain tools and platforms. Performing a needs analysis of digital device access at the start of a course is essential as this can help deepen understanding of any real or potential barriers to engagement (Goodall, 2018). In addition, when asked, only 13% of participants revealed that they had taken a CS course in secondary school.

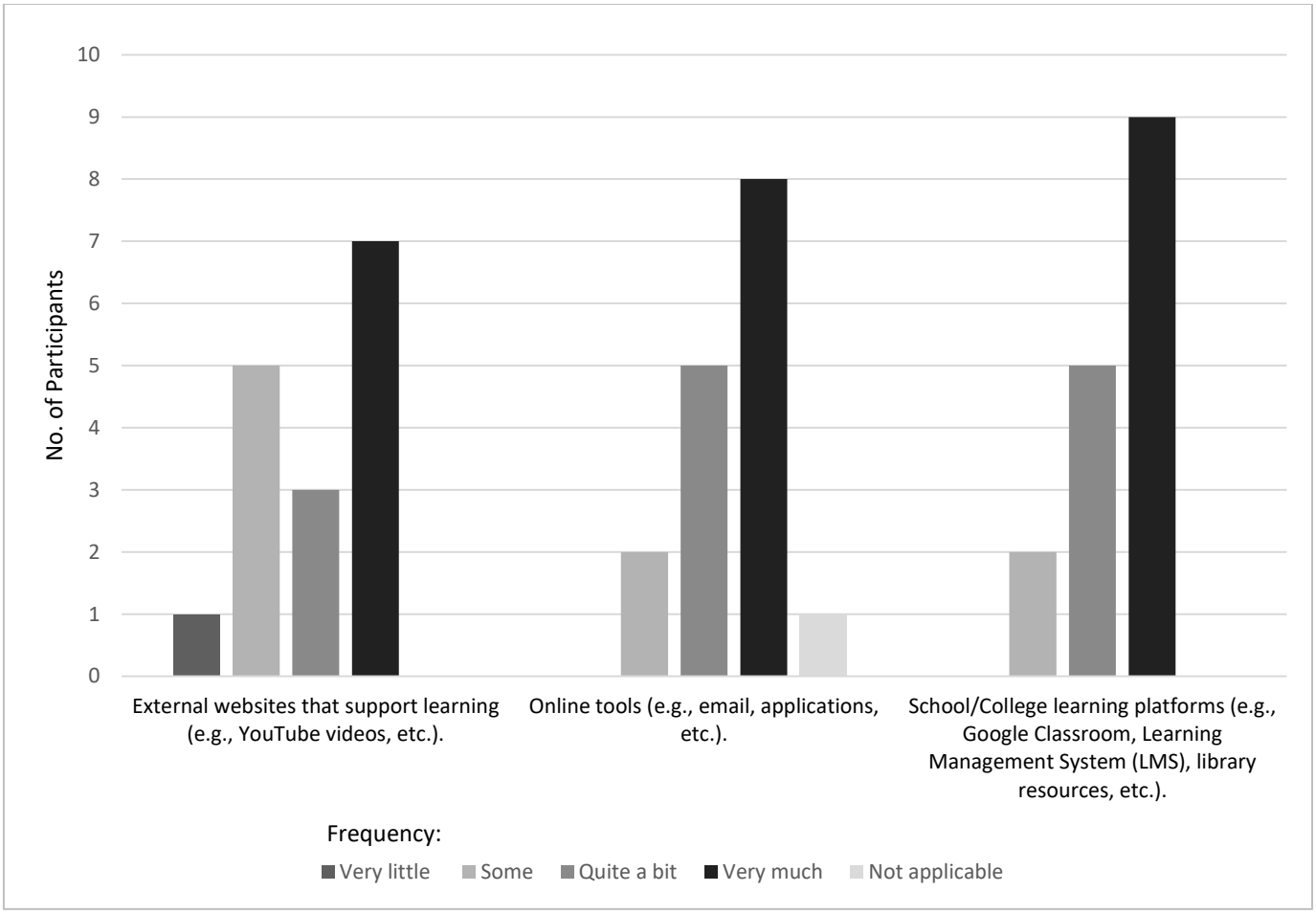


Figure 4.2: Previous Use of Digital Resources

4.2.2.2 Why are Learners Studying Computer Science?

Skills, Employment and Career Sustainability

All seven participants in the focus group interview believed that by studying CS they would develop skills that would be relevant in the job market for the next 30 to 40 years, with participants believing that future opportunities in computing are without boundaries. Furthermore, they thought that a career in technology has the promise of being financially rewarding. All seven participants felt that by studying CS, goals of being employed and having a sustainable career could be achieved, and concerns regarding being unemployed would be addressed.

> *Studying CS and having a career* [in Computer Science]*, financially it could be good and allows you to have a broad career, getting a great job, great money. Computer scientists are very much in demand, they are a valuable group. This skill is so valuable. And this will help us with many kinds of jobs* (Participant 1).
>
> *…if I want to have a long career that would be valuable and still be here after a long time as well. And also the money is good. The field is very broad, and you can branch off into different departments* (Participant 2).

Diversifying Academically

Several participants discussed the need to diversify academically, which involved expanding their range of academic courses and degrees (outside of CS as a major subject) so that they might have a wider range of job opportunities.

> *So firstly, I want to get through these three years and get a job. Get some experience, get some money, and then continue my studies, so keep going. I want to branch out, that's my plan* (Participant 2).

> *I was speaking to an international investment broker company, and they were saying that we need programmers, not just for the programming aspect but in terms of investment skills and having a business degree. I want to move more into investments, economics, accounting but in terms of programming* (Participant 3).

Obtaining a Good Grade

In the post completion Questionnaire B (see Appendix B), over 80% of participants indicated the importance of accomplishing the learning objectives and doing well. This was an overarching concern, which also came through in the focus group interviews and through observations and discussions with participants.

4.2.2.3 Outside Motivational Factors Influencing Learners

In the focus group, participants discussed certain factors in their background that had been helpful in relation to their concerns. Two participants discussed the importance of role models offering guidance, and one participant mentioned how they draw inspiration from "revolutionary figures", whilst another discussed the role of family, friends, and mentors.

> *Steve Job's book, inside the mind of Bill Gates* [book]*, Steve Wozniak's book, revolutionary figures. What they did in order to get to where they are now* (Participant 3).

Participant 3 agreed that researching what inspirational figures did to get to where they are now was incredibly motivational.

> *My neighbour, she also does IT, she was telling me like you know what, this field is actually a great field, she was the one that told me that it is broad* [field] *and motivated me to study something that will secure me for the rest of my life. I credit my dad as well, he said to me I don't have money for you to keep on repeating courses, he said you only have three years and that's it. And if you don't make it you will have to return home and become a farmer, and I don't want to do that, so that's my motivation* (Participant 2).

4.2.3 Constraints that Contribute to Disengagement

4.2.3.1 Myself

Participants were asked if they had noticed anything that could create an obstacle in relation to their concerns. One participant felt that the only obstructive influence was themselves. This speaks directly to learner ownership of their learning.

> *Except for myself, I can't think of anything else* (Participant 2).

This sentiment also came through in the predesign Questionnaire A (see Appendix A), where a number of participants also described what they considered to be the most important factor contributing to their learning and development at college and why it was important to them. Participants stressed the importance of self-motivation and allocating sufficient time to fully engage with the learning process.

> *Personal motivation to teach myself content in and out of class. I wouldn't be able to have a thorough education through pure studying alone* (Participant 5).

> *The biggest factor in my learning is scheduling time to read or engage with my study material* (Participant 6).

In the predesign questionnaire, when asked to define engagement, one participant indicated that learner agency in the form of the learner's interest level was an important component.

> *The learner's interest in learning and how much the teacher can keep them invested in the work that they are doing* (Participant 3).

4.3 Part 2: Views on Engagement (Predesign)

Part 2 considers learners' understanding of engagement and factors they perceive to be important when engaging with learning activities and a course. Investigating learners' understanding of engagement and factors they perceived as important occurred before the design and development of the learning activities (Stage 1 - predesign).

4.3.1 Understanding of Engagement

In the predesign questionnaire, participants were asked to define engagement. This was asked to establish whether participants had a general understanding of learner engagement, and secondly to identify the characteristics highlighted by the participants when defining engagement.

Nine participants (56%) indicated that engagement is defined by the communication or interaction between their lecturer and their peers, and highlighted the connections being formed. The ability to ask questions was also indicated as an important aspect of engagement.

> *Interaction between learner and teacher in both directions* (Participant 8).

The mutual relationship the lecturer has with said learner without fear of judgement if the learner struggles to grasp a concept (Participant 10).

Learners getting to know each other and form an educational bond, all together with the teachers (Participant 12).

Five participants (Stage1 – predesign) mentioned the role of learning activities with regard to engagement:

Asking [a] *question when lost and engage in an activity given by lecturer* (Participant 2).

Prompting learners to answer questions and giving them activities/homework to get a better understanding of where they stand in the class (Participant 6).

Learners asking questions and participating with intent in activities (Participant 4).

4.3.2 Most Important Aspects to Support Engagement

Access to Lecturer Support

In the predesign questionnaire, participants were asked what they would find helpful in order to engage with the learning activities and the course. Twelve participants (75%) felt that support is particularly important (Figure 4.3).

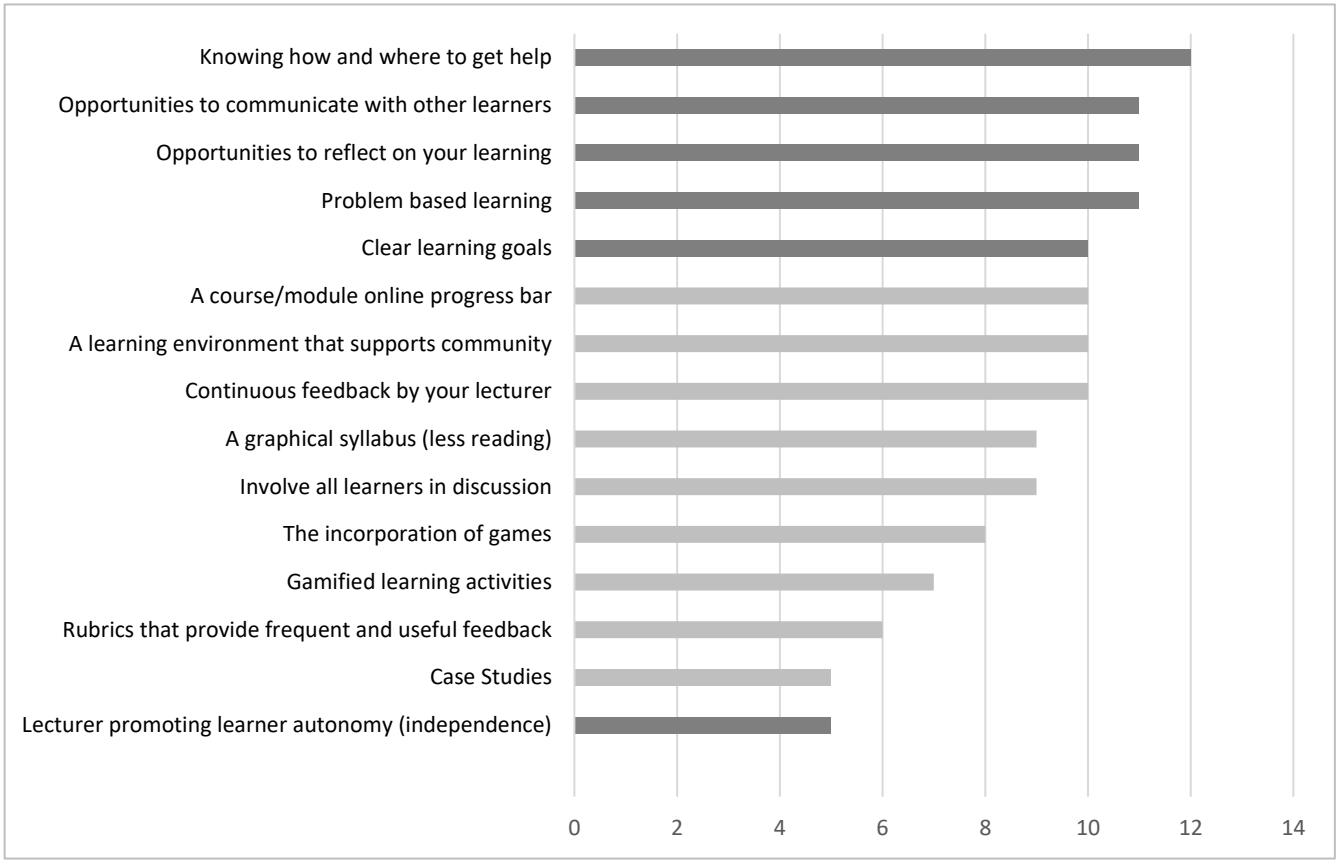


Figure 4.3: What Participants Found Helpful to Engage with Learning Activities

This was identified in another question, in which participants were asked to explain what they perceived to be the best aspects of learning activities and engaging with course content:

> *The support that the lecturers give and never getting frustrated at learners when they ask for help or do not understand the work* (Participant 13).

Lecturer Feedback

The role of feedback was highlighted when participants were asked what they preferred when working through a learning activity, with 14 participants indicating the need for lecturer feedback after each learning activity (Figure 4.4).

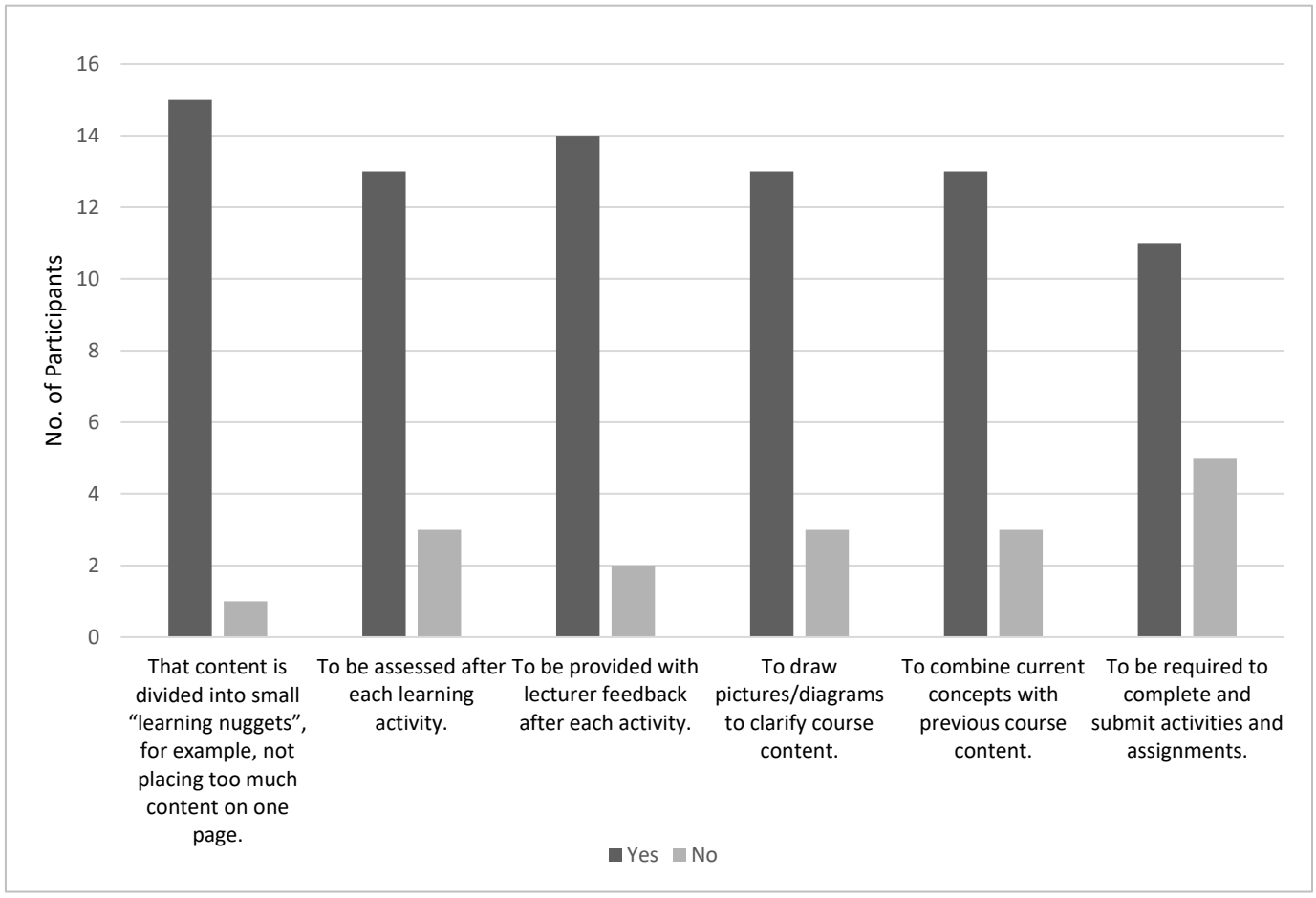


Figure 4.4: Participants Preferences Regarding Learning Activity Features

When asked to consider what were the best aspects of how learning activities engage learners, two participants (predesign stage) expressed the importance of being able to communicate and receive feedback in a non-threatening environment:

> *When the teacher explains a topic to you personally after you have failed to understand it* (Participant 8).

In addition, 10 participants (predesign stage) stated that it was particularly helpful to have continuous feedback from their lecturer (Figure 4.3).

Tracking progress

One participant (predesign stage) referred to the role of being able to monitor learning progress:

> *When a problem is given after learning something new, especially if the topic was an important one. Being able to feel and see that you are capable, or incapable provides a grounding feeling over what you do know, need to know and want to know* (Participant 4).

Ten participants (predesign stage) agreed, believing that a course/module online progress bar is beneficial Figure 4.3).

Opportunities for Reflection

Eleven participants (predesign stage) stated that opportunities to reflect on their learning was particularly helpful, with two participants expressing that opportunities for the lecturer to guide them to identifying areas of improvement were important.

Collaboration with Peers

In the predesign stage, when asked what they found particularly helpful to engage with course content, 11 participants (69%) expressed the role of communicating with other learners as being vitally important (Figure 4.3). Moreover, 10 participants (63%) were of the view that creating a learning environment that supported community building was helpful (Figure 4.3).

Group Work

In the predesign stage, three participants mentioned aspects of group work, expressing that group work facilitates engagement with a learning activity:

> *Working on activities in pairs, engages the creative aspect of the brain, and allows socialising* (Participant 3).

> *Group work helps learners to be able to listen and acknowledge different ideas and point of views* (Participant 12).

This also became apparent when a participant described what they considered to be the most important factor contributing to their learning and development at college and why it was important to them:

> *Tied between lectures and self-study. Love a good lesson, but also working with friends is great fun and helps me learn a lot. I love the idea of a study buddy, definitely try encouraging partnered studying or groups* (Participant 12).

Problem-Based Learning

In the predesign stage, when asked what they found particularly helpful to engage with course content, 11 participants agreed that problem-based learning was beneficial (Figure 4.4). This was also indicated when participants were asked to describe what they considered to be the best aspects of how learning activities engage learners; two participants (in the predesign stage) mentioned the role of problem-based learning, and that the level of difficulty must be attainable.

Practical, Real-World Examples

When asked what they find particularly helpful to engage with course content in the predesign stage, four participants highlighted the need for practical, real-world examples:

> *Enables the learners to practically get involved and understand work better* (Participant 2).

> *When an educator shows real-world examples* (Participant 5).

Least Important Aspect to Support Engagement

In reference to the aspect chosen least by participants, as depicted in Figure 4.3, only five participants (31%) selected the promotion of learner autonomy (independence) by the lecturer. This is of particular interest as to a certain degree this validates the top two selections – namely, opportunities to communicate with other learners, and knowing how and where to get help. Furthermore, it supports the findings that participants viewed support and guidance from the lecturer and fellow learners in the learning process as being critical and fundamental.

4.4 Part 3: The Learning Activities and the Course (Post-Implementation)

Part 3 delves into participants' thoughts on the activities and the coursework towards the end of the course. The focus is on the participants' views of how their engagement increased and/or decreased. Therefore, the findings in this part are related to the learners' evaluation of the implemented learning activities and the course within the context of engagement. A summary is provided at the end of Part 3 in the form of a theme map that represents the overall findings drawn from the data gathered in the field notes, questionnaires, and the focus group interview.

4.4.1 Levels of Engagement Related to the Learning Activities

After the completion of the learning activities, participants indicated which learning activity they felt was the most engaging (Figure 4.5). Learning Activities 1 and 3 scored higher than the other two. In addition, 59% of participants strongly agreed that Learning Activities 1 and 3 were the most engaging.

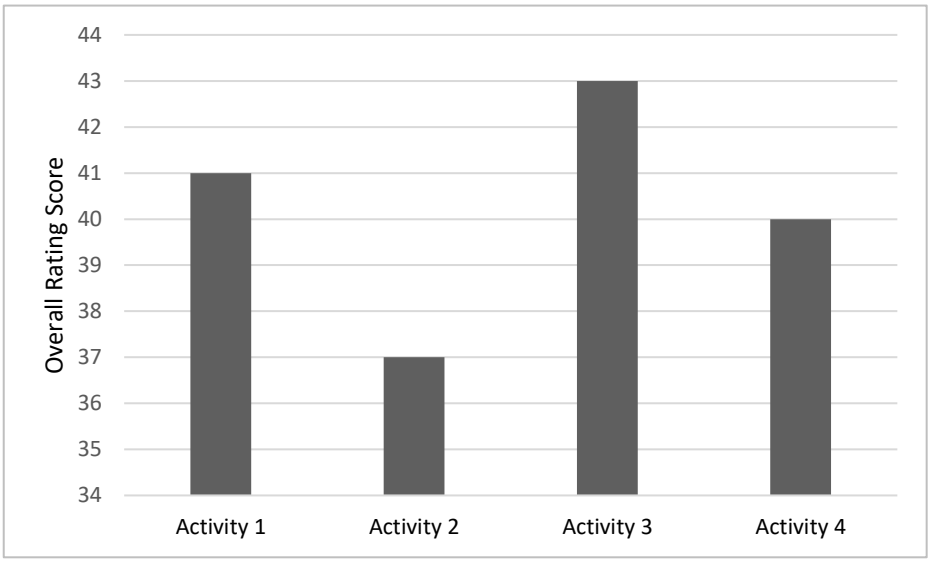


Figure 4.5: Learning Activity that Participants Felt was Most Engaging

However, when looking at the percentage of each learning activity completed, most learners (94%) completed Learning Activity 1, whereas far fewer (61%) completed Learning Activity 3 (Figure 4.6). Possible reasons for this will be discussed in Chapter 5, however it is important to note that for Learning Activity 1, learners were given a choice to either work alone or work in a group. Sixty percent of the learners opted to work in a group, with the other 40% choosing to work individually.

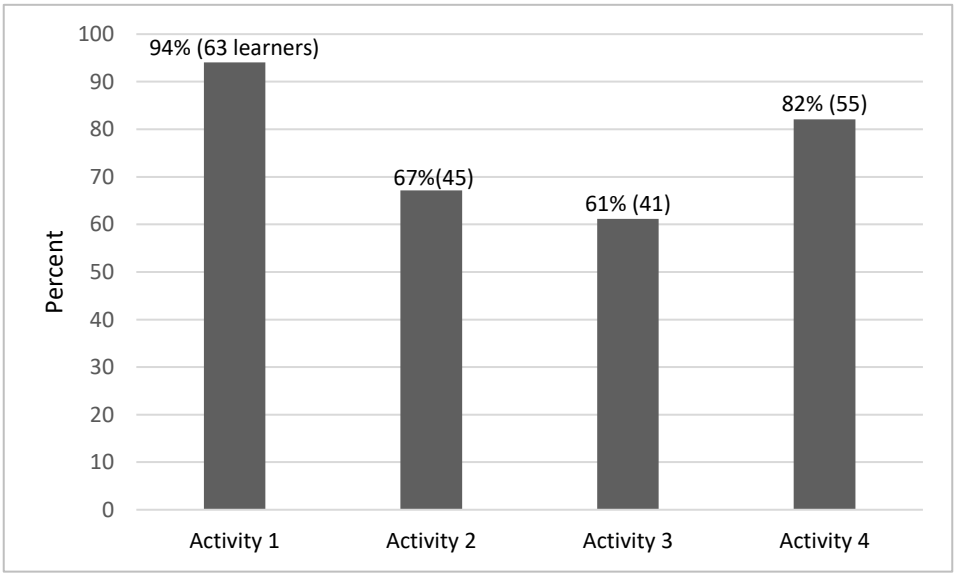


Figure 4.6: The Percentage of Learners who Completed Each Activity (n = 67 learners)

In terms of the learning activity completion ratio, 77% of learners engaged and submitted at least three out of the four activities, with 43% of learners completing all four activities. Seven out of 67 learners (10%) completed only one learning activity (Figure 4.7).

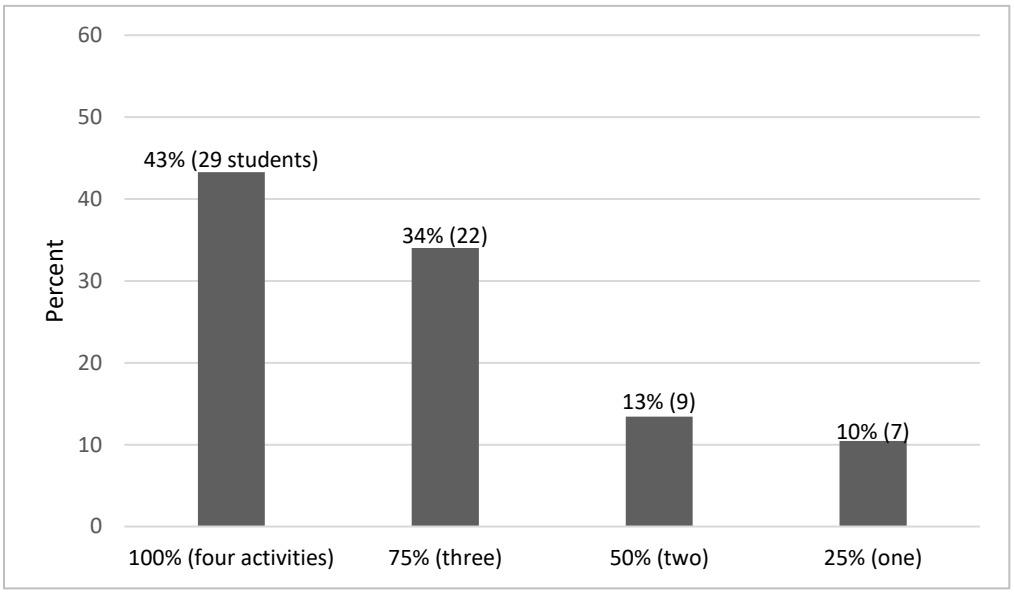


Figure 4.7: Learner Activity Completion Ratio (*n = *67 Learners)

4.4.2 A Closer Look at Each Learning Activity

As depicted in Figure 4.8, all participants (*n* = 16; 100%) agreed that when completing the four activities, they tried to contextualise and relate what they were learning to what they already knew. Furthermore, they said they intended to use what they have learnt from completing the activities. Other notable agreements among participants were that the learning objectives were clear (88%), the activities stimulated their learning (81%), the activities provided sufficient practice (81%), and that there was a feeling of being involved in the learning activities (88%).

Although 88% of participants agreed that the learning activities were a good way for them to learn content, only nine participants (56%), agreed that when completing the activities they tried to connect what they were learning with their own experiences (Figure 4.8). In addition, only 10 participants (63%), agreed that the activities provided sufficient feedback. This is of relevance when considering the importance participants placed on feedback in the predesign stage. Moreover, it highlights where improvements with the learning activities may need to be made.

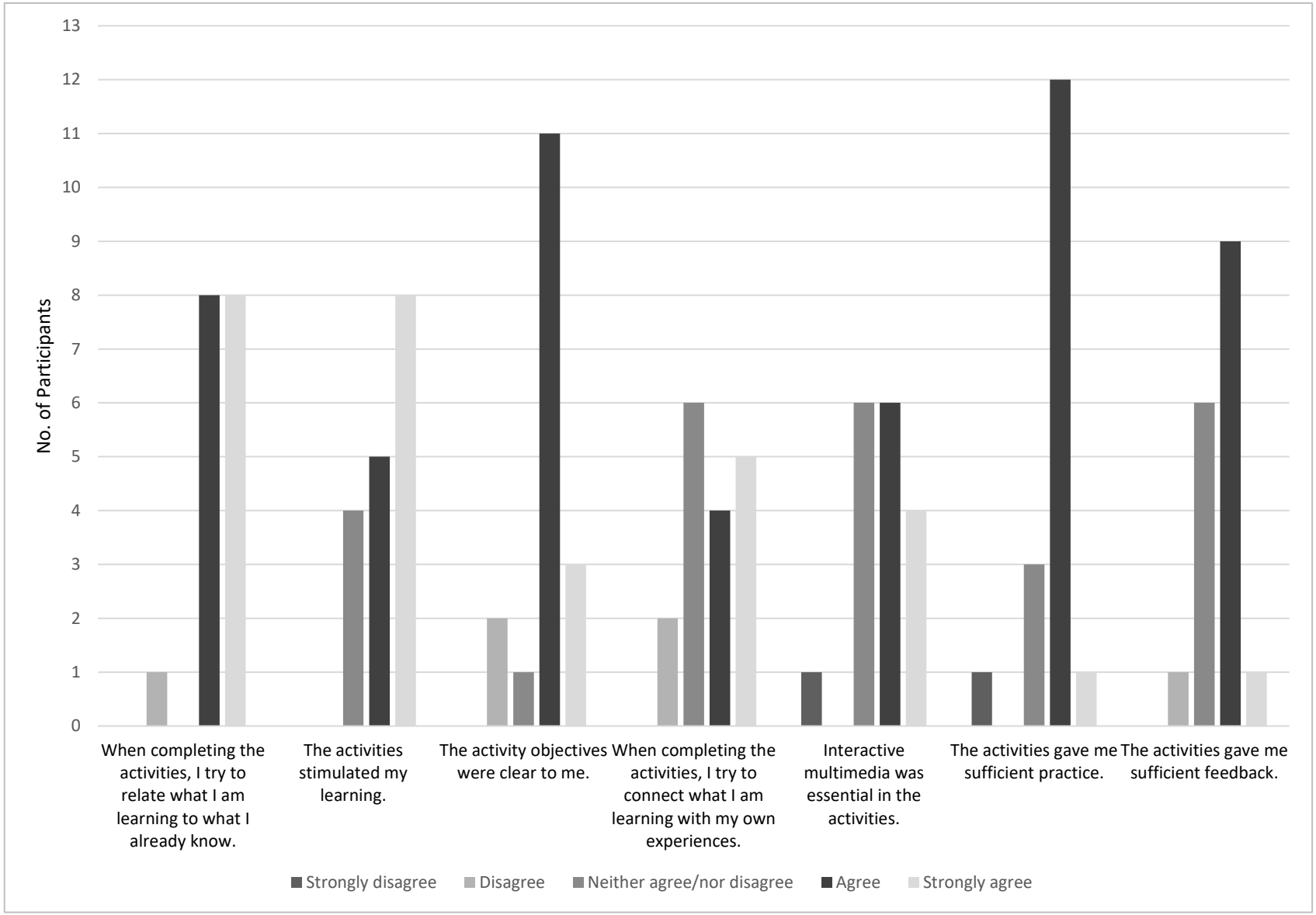


Figure 4.8: Behaviours, Thoughts, and Feelings after Completing the Four Activities

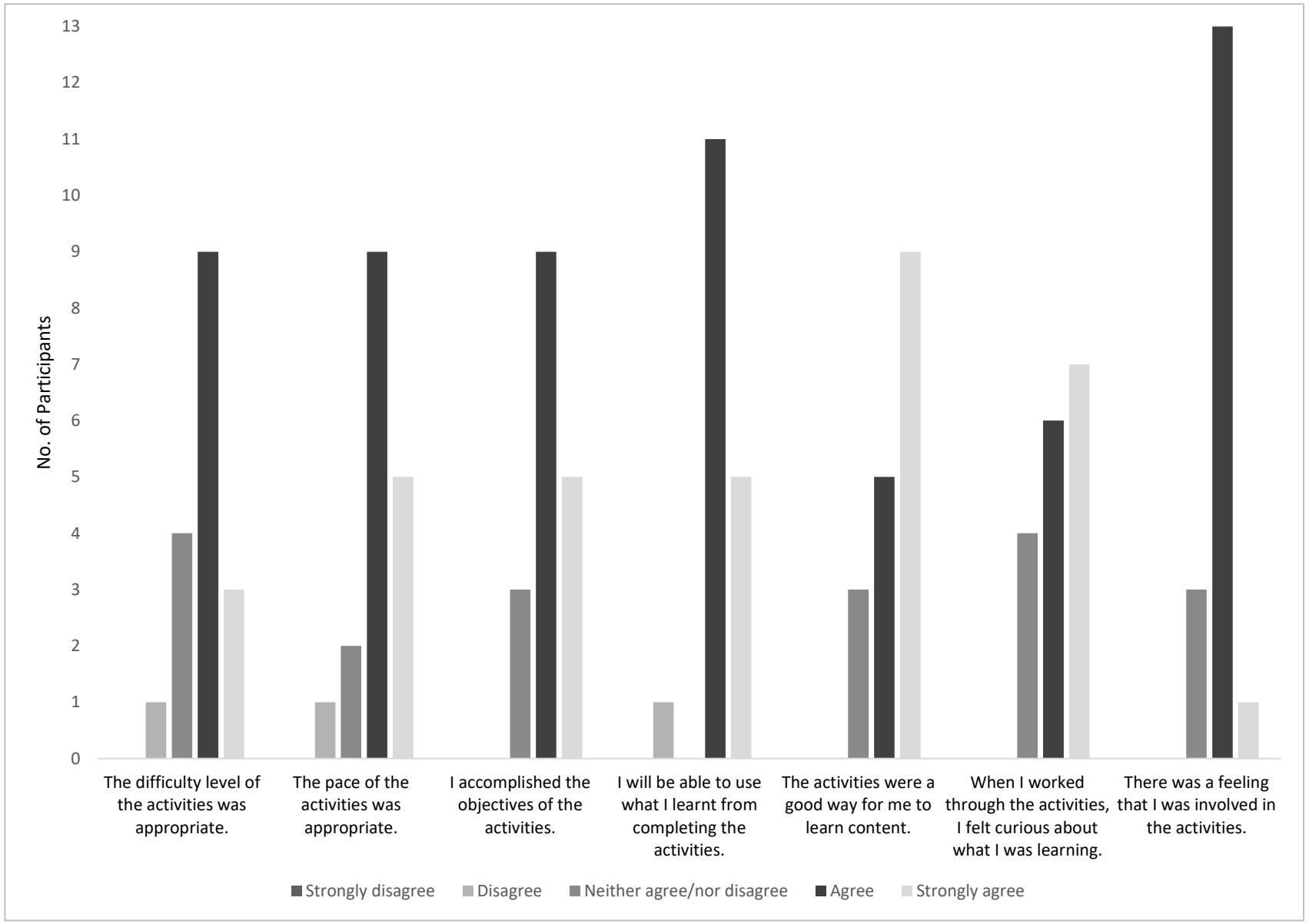


Figure 4.8 continued: Behaviours, Thoughts, and Feelings after Completing the Four Activities

In the focus group Interviews, participants were asked to consider the four activities, and indicate which features in the activities they believed assisted them the most when engaging with the course content.

Learning Activity 1

Two participants noted that Learning Activity 1 was engaging as it helped them to consolidate their learning:

> *I liked the first activity. It helped motivate me and build my curiosity. It contributed to making sure I correctly designed pseudocode and flowcharts* (Participant 1).

> *As for the pseudocode and flowcharts we did in Visio* [Activity 1]*, in the beginning it was kind of difficult and frustrating to figure it out, but it was helpful because I could work in my own time and try do it myself* (Participant 2).

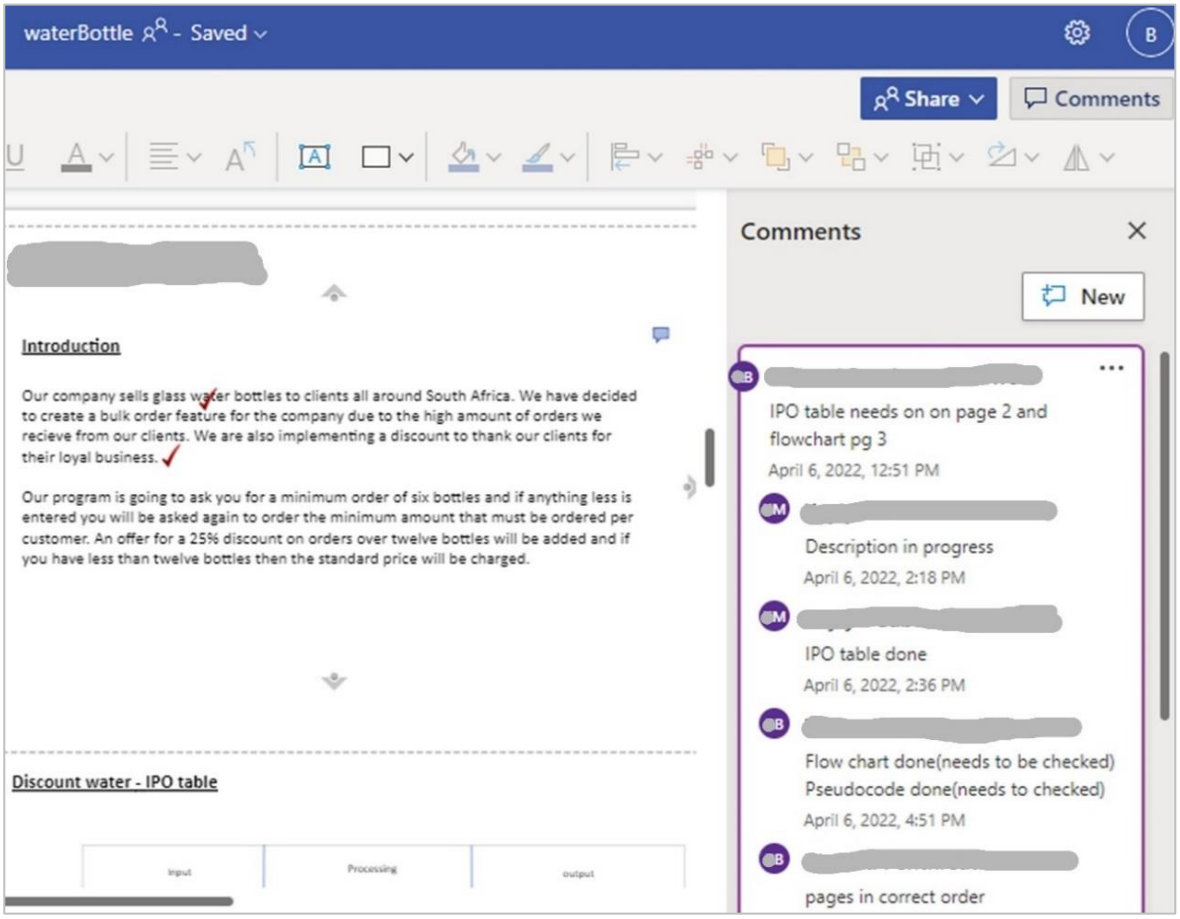


Figure 4.9: Learning Activity 1 – Microsoft Visio Group Interaction

In addition, learners were given the opportunity to work in a group or by themselves for this learning activity. More than half (59%) of learners elected to work in a group consisting of either two or three members. The interaction amongst members is seen through observing the documentation submitted in MS Visio (Figure 4.9). MS Visio provided a platform whereby learners could communicate and collaborate beyond the physical borders of the

classroom. This interaction also provided an opportunity for learners to provide feedback to each other through the comments section. This interaction is date-and-time-stamped to see the frequency of engagement. As indicated in Figure 4.10, Microsoft Visio also allowed for online grading and lecturer feedback. As it was a live document, learners could in turn request clarity on the feedback through the comments section.

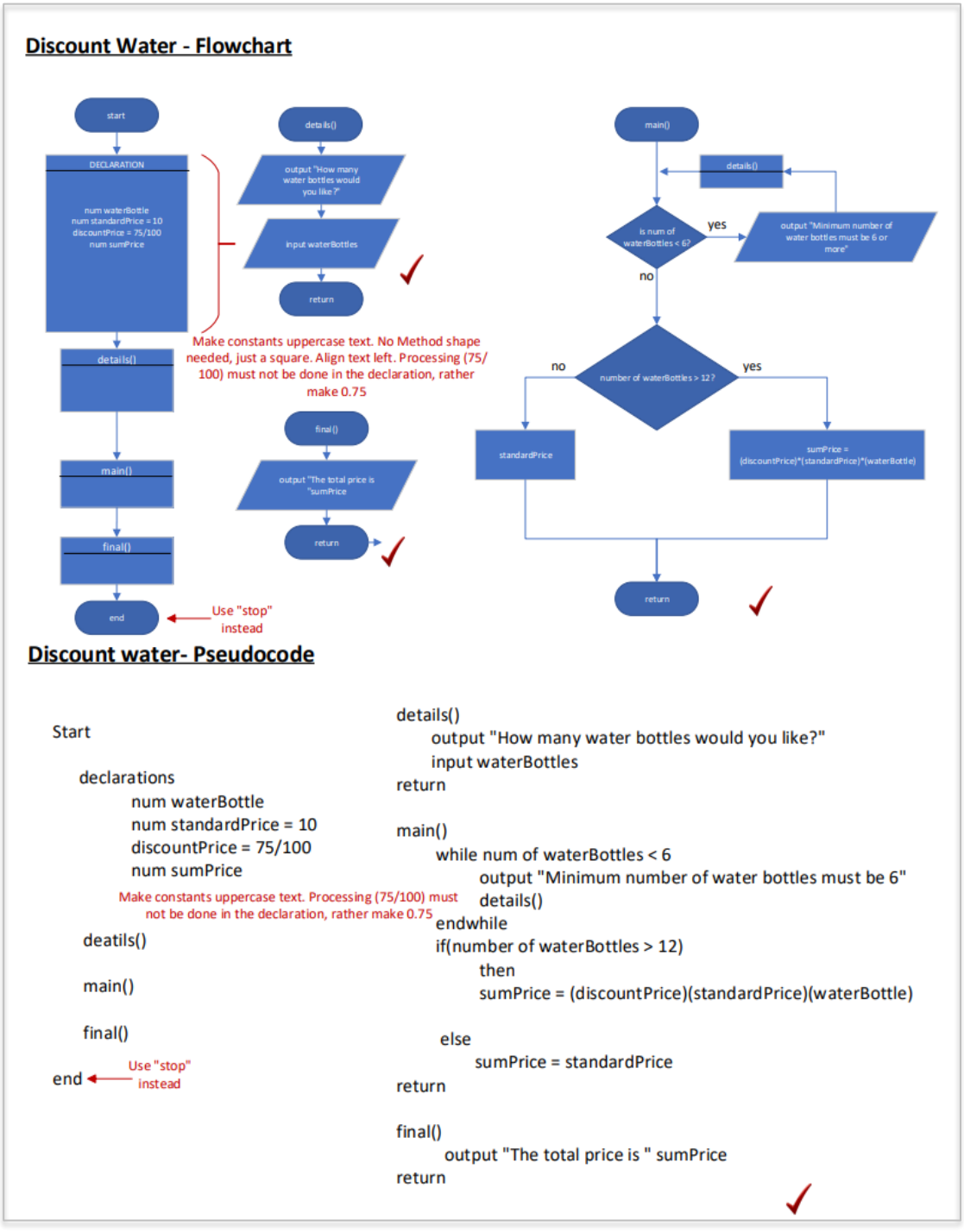


Figure 4.10: Example of Learning Activity 1 Feedback

Learning Activity 2

For Learning Activity 2, the focus group of seven participants agreed that the entertainment value of a gamified quiz and the advantages of receiving instant feedback compelled them to engage further:

> *With the second activity, gaming is a fun thing. Getting feedback if you choose the correct answers, raises the learning experience* (Participant 1).

> *It wasn't my favourite although it was quite entertaining. It motivated me to go through it a few times to get full marks and the top score, it was competitive* (Participant 2).

The focus group agreed that having time-appropriate learning activities, and more specifically having time-appropriate questions in activities, made the learning activity more challenging and increased their engagement. Furthermore, having a scoreboard in the learning activity increased their competitive drive. However, participants felt that the time limit per question, particularly in Learning Activity 2, was inappropriate and that this would need to be looked at. Participant 3 agreed that the validity of the [gamified quiz] test drops when you implement a time that is too short:

> *We needed more time and space in order to look where am I sourcing this from in the textbook or the notes* (Participant 3).

Learning Activity 3

In the focus group, several participants described how Learning Activity 3 inspired them to research a topic further, and engage more in an online discussion with fellow classmates:

> *I really had to do a lot of research for this activity. I find that if it goes outside of normal stuff. Because normally it's like a game, create numbers or something, but when it goes outside the normal, for example discussing the topic of transplants* [Activity 3]*, that's engaging* (Participant 4).

Participants agreed that Learning Activity 3 encouraged them to think in different ways and the questioning approach was a deviation from the traditional style of questioning related to flowcharts and pseudocode:

> *This* [Learning Activity 3] *was based on a real-world problem, where you must think and make sure you can do research that will help you figure out stuff. You need to understand how something works before you can implement it in your program* [design] (Participant 2).

Evidence of this type of engagement and research for Learning Activity 3 is seen in Figure 4.11, by observing the depth of discussions and research that took place on the LMS when completing Learning Activity 3. Engagement

levels may be seen through rigorous debate, whereby learners are disagreeing and/or agreeing with points made and contributing with additional points.

RE: c) Decisions to be made

- the first recipient on the waiting list may get the organ they need for transplant

- Are they compatible with the organ available to them?

RE: c) Decisions to be made

I disagree I think urgency overrules time on the waiting list what if somone has been given 2 months to live and the person that is next to recieve on the list has 3 years?

There should be a decision for that don't you think?

RE: c) Decisions to be made

I dont think first come first serve should be an option in considering a patients life is at stake

RE: d) Kinds of data to be excluded

Surely nationality should be considered as if you are not from that country

why should you qualify for an organ unless you have resident permits.

Also often goverment subsidies that reduce hospital costs for citizens of

the country and the hospital will need to show that information.

Via ID number or passport number.

RE: d) Kinds of data to be excluded

i think religious beliefs and nationality should be considered

because if they are illegal immagrants then you by law cannot

obtain an organ and some religious beliefs go against blood

transfusions which would be a breach of consent.

RE: d) Kinds of data to be excluded

Reasearch states that men and womens vital organs differ in size and effiency.

For example men have larger hearts and lungs as well as brains.

Women also have a bigger kidneys and thyroid glands than men and this is just to name a few.

Therefore I believe that the donor and recipients gender should be considered with reagards to organ donation. :)

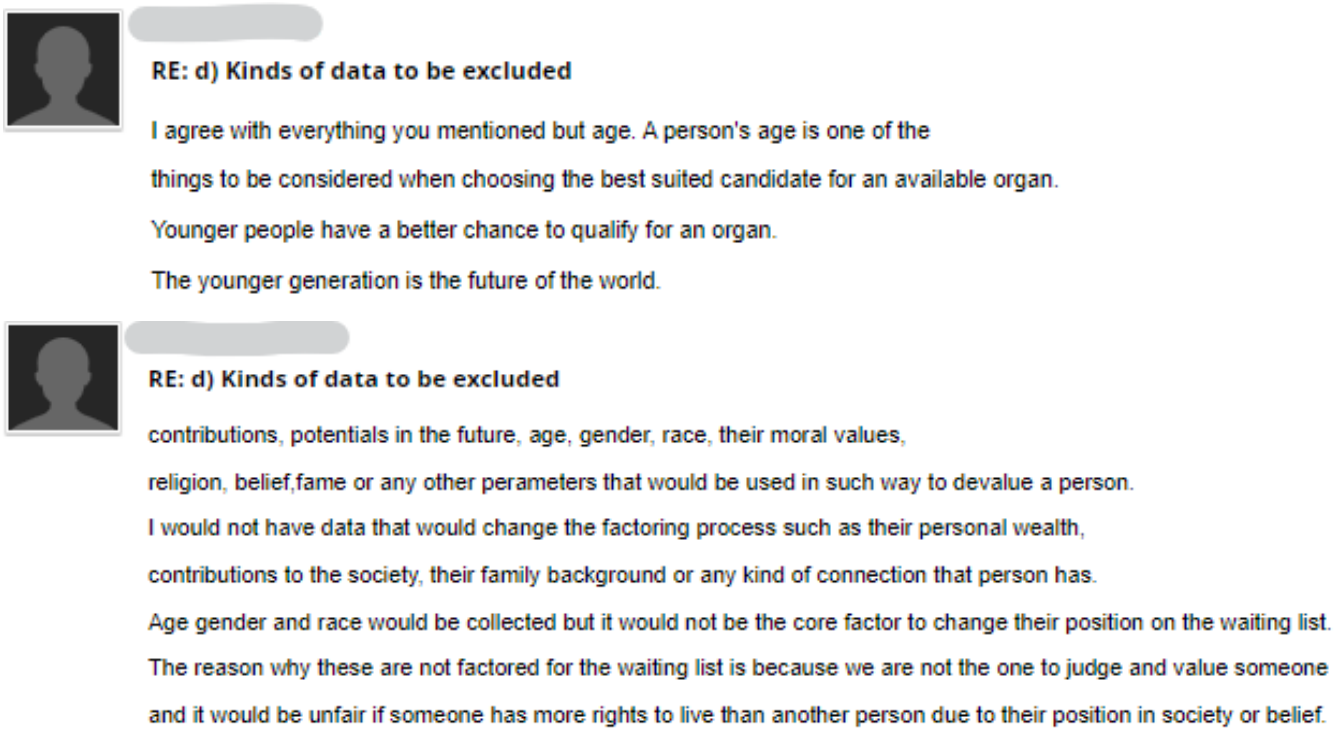


Figure 4.11: Learning Activity 3 LMS Observation

Learning Activity 4

In the focus group, participants agreed that Learning Activity 4 was beneficial as it offered exam style questions within a learning activity, and would help them prepare for the upcoming assessment.

> *The arrays* [Learning Activity 4] *was my favourite because it was like an exam setting where you had to go through everything and then lets you see what you can get at the end. I was drawn to that more* (Participant 2).

4.4.3 Where Engagement Increased and/or Decreased in the Learning Activities

Participants in the focus group indicated whether their engagement had increased, decreased, or stayed the same. As discussed in this chapter, some participants felt that their engagement with the activities was related to their personal motivation. Participants also mentioned areas where their engagement had increased and/or decreased in relation to contextual issues outside of the classroom.

4.4.3.1 Increased Engagement

Participants in the focus group felt that their engagement with the learning content had increased, as the structure of the activities enabled them to improve and consolidate their learning, and this in turn motivated them to engage further.

These activities did increase my engagement, as it aided in enriching my skills. It helped me to improve, even though mistakes were made (Participant 1).

I'm not willing to go look for activities to go through by myself. For any subject in this way. So, it was quite useful for me (Participant 2).

This increase in engagement was supported when in Questionnaire B participants were asked to highlight and elaborate on what they enjoyed the most when working through the learning activities. Three participants explained how the activities encouraged them to contextualise and relate what they were learning to what they already knew:

The activity made me apply what I had learnt in class (Participant 5).

Testing myself and building upon existing knowledge to answer questions about unknown topics (Participant 9).

One participant highlighted the interactive format of the activities that promoted reflection:

The format is new and different making it less boring than other tasks and makes you think more about your answers because of the creative format of the questions, it was actually enjoyable (Participant 7).

Two participants mentioned problem-based learning that required research:

The researching process, problem solving process (Participant 14).

In the focus group, participants acknowledged the relevancy of the course and why it was important to increase engagement. Participants felt that the course provided an opportunity for them to develop their problem-solving skills and gain confidence in algorithm design. They expressed the importance of this as it forms the foundation of coding and makes programming easier.

Programming logic and design is the building blocks, it helps us with the planning about programming. If we have a programming issue, we can ask, how can we plan to solve the problem? And how can our design, such as pseudocode, help to try make it work and then try it in the code (Participant 1).

*I agree, it makes programming easier because it helps with your understanding of structures. In my case it made a big difference (*Participant 2).

Participant 2 agreed that having the logic in place forms the foundation to making programming easier:

…because the logic is still the same whether you're using Java or another different programming language (Participant 2).

4.4.3.2 Decreased Engagement

In Questionnaire B, participants were also asked how they would improve the activities so that they are more engaging. Two participants indicated the need for more real-world relatable scenarios that would require additional research:

> *Create unique scenarios for less engaging activities which encourages learners to do more research by themselves* (Participant 8).

> *By including more relatable scenarios* (Participant 16).

One participant suggested the use of trick questions as an extension to challenge learners:

> *By adding trick questions* (Participant 2).

Home/Online Environment vs College Environment

The majority of the participants in the focus group felt that disengagement increased when at home, whereas engagement increased when at college. Participants elaborated on their home environment, from the technical issues they encountered, to distractions from family members. Furthermore, they felt that that the optimised learning environment provided at college had a direct impact on their engagement level.

> *Online is just a mess. Your Wi-Fi drops, someone comes into your room to ask you something, whereas here at college, it's a set time where no one is going to try get hold of you* (Participant 3).

The focus group agreed that the comfortable environment at home creates many distractions, and this resulted in disengagement.

> *There was a study done about how your mind associates home with generally relaxing, and then the work environment is where you work and you are active and when you go home, your mind, no matter what you do, goes into that sort of relaxed, calming, tranquil environment. Whereas here* [at college] *it's like ok, I need to learn, I need to get my things in order* (Participant 3).

Lack of Support

Within a blended learning context, participants indicated that there was a lack of support in the form of opportunities to ask a lecturer questions and this resulted in disengagement.

> *When online it's not easy for me to understand. Sometimes I would like to ask a question personally to the lecturer and not like the entire group. Say I ask a silly question, I am scared to ask the question in an online environment, because everyone is going to think why don't you know anything* (Participant 1).

> *At college we are fortunate, we know we get* [face-to-face] *class time and we get more time with the lecturer, we can ask, can explain to me. So, it is better when I am here, I am focused in this learning environment* (Participant 2).

This decrease in engagement was supported in Questionnaire B, in which participants were asked to explain what they enjoyed least when working through the learning activities. One participant felt that the activities could be more challenging, however another indicated the need for more support:

> *The activities could have been a bit more challenging* (Participant 4).

> *I found it a bit difficult because I needed more help* (Participant 3).

One participant indicated that time was a factor, especially with Learning Activity 2:

> *I would have preferred more time with MCQ* [multiple choice questions] *to compare with the notes to read/understand* (Participant 5).

The objective of this learning activity was for the learners to go through their notes prior to attempting the gamified multiple-choice questions, which highlighted the need for learners to read for understanding before attempting questions.

Logistics: Travel Costs

One participant in the focus group mentioned that their engagement increased when learning was online due to the cost involved with getting to and from college:

> *So online* [learning] *helps with travelling time and expenses* (Participant 1).

This was also mentioned in the predesign stage, in which a participant indicated that a combination of attending face-to-face lectures and accessing recorded lectures was the most important factor contributing to their learning and development at college.

4.4.4 Relationship between the Learning Activities and the Course

The OSE results indicated that 88% of participants agreed that doing well on the activities, assignments and tests, getting a good grade, and finding ways to make the course interesting to them, was either characteristic or very characteristic of them (Figure 4.12). Eighty-two percent of participants felt that listening and reading carefully was important. In addition, 76% of participants indicated that putting effort into their studies, with a strong desire to learn the material, and helping fellow learners, was fundamental.

In many ways, these findings align with the findings expressed by participants regarding their behaviours, thoughts, and feelings associated with the learning activities, with over 80% of participants indicating the importance of accomplishing the objectives of the learning activities and doing well. They reported the importance of being involved and trying to relate what they were learning to what they already knew. In addition, 75% of participants in the predesign stage indicated the role of support as a critical factor for engagement, such as knowing how and where to get help.

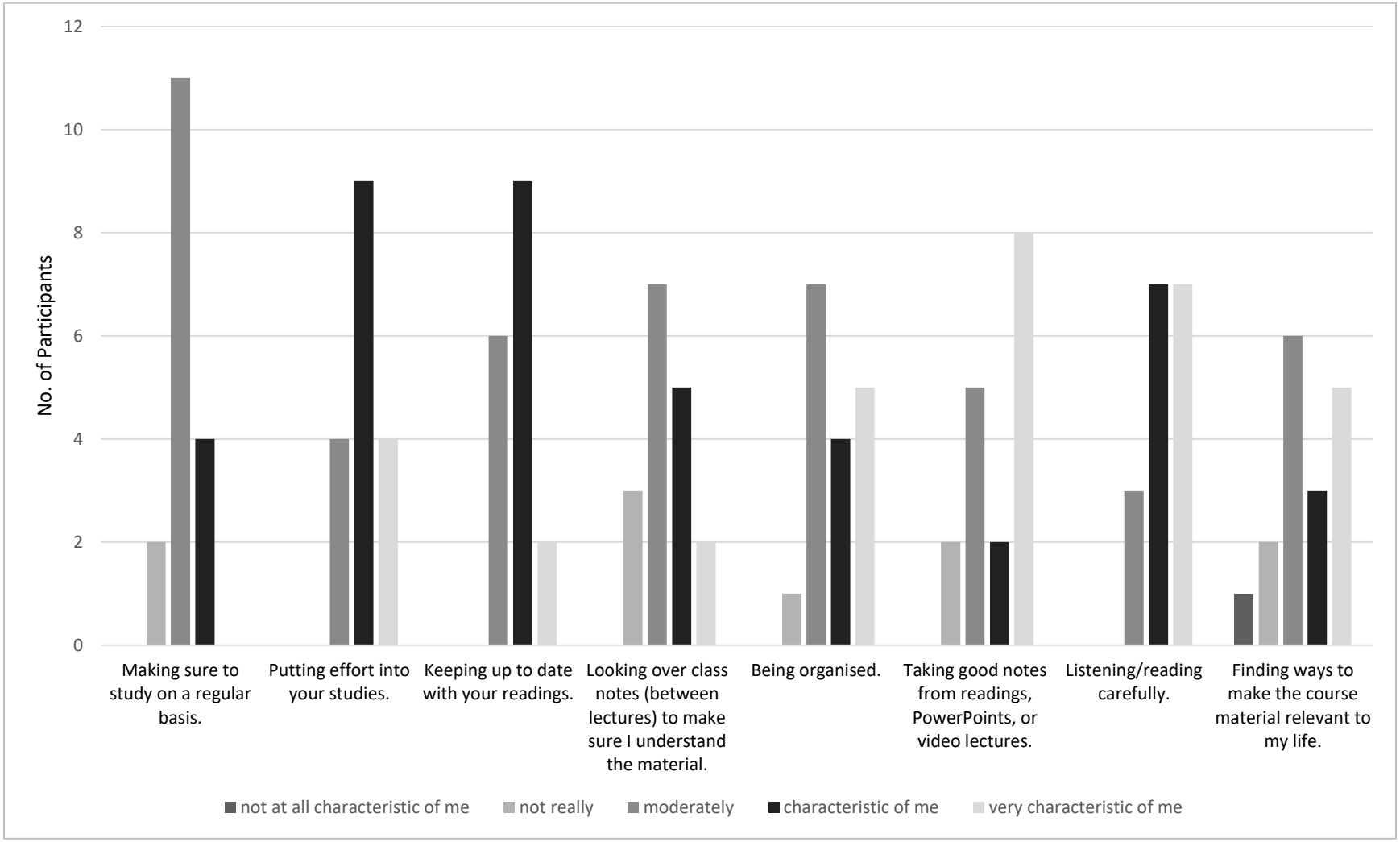


Figure 4.12: Behaviours, Thoughts, and Feelings Regarding the Course – OSE Results

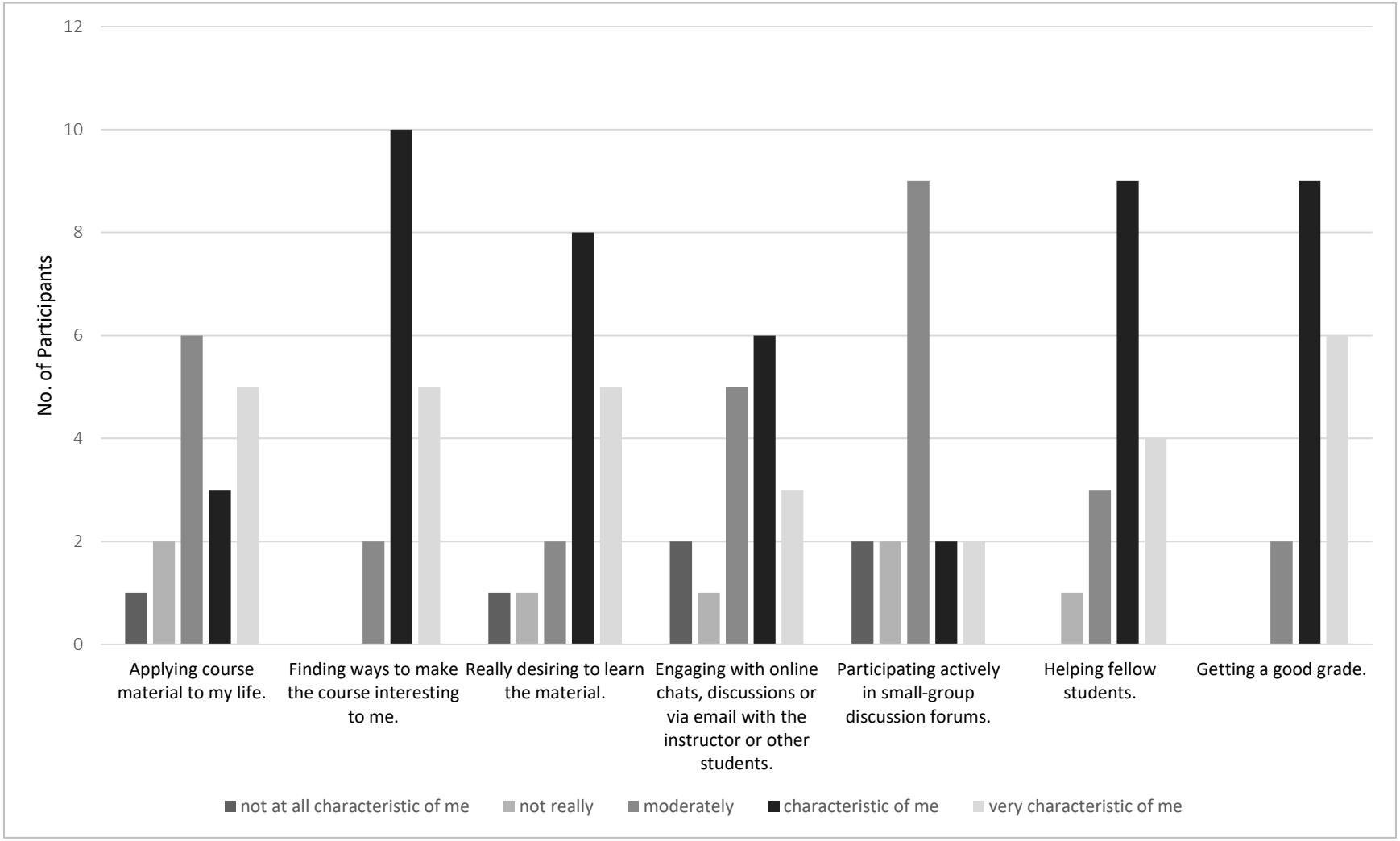


Figure 4.12 continued: Behaviours, Thoughts, and Feelings Regarding the Course – OSE Results

4.5 Summary

Findings drawn from the data gathered in the questionnaires, the focus group interview, and the field notes indicated factors that influenced engagement. This data revealed certain consistent themes in relation to the learning activities, agency, and blended learning within the course, as depicted in Figure 4.13. Prominent influences (themes) such as the need for problem-based learning (PBL) and real-world practical examples, learner support, clear learning objectives, and influential figures on learner engagement will be explored and discussed alongside the findings from previous research by other academics in the following chapter. Moreover, these influences will be framed according to Archer's (2003) theoretical framework of cultural, structural, and agential dimensions.

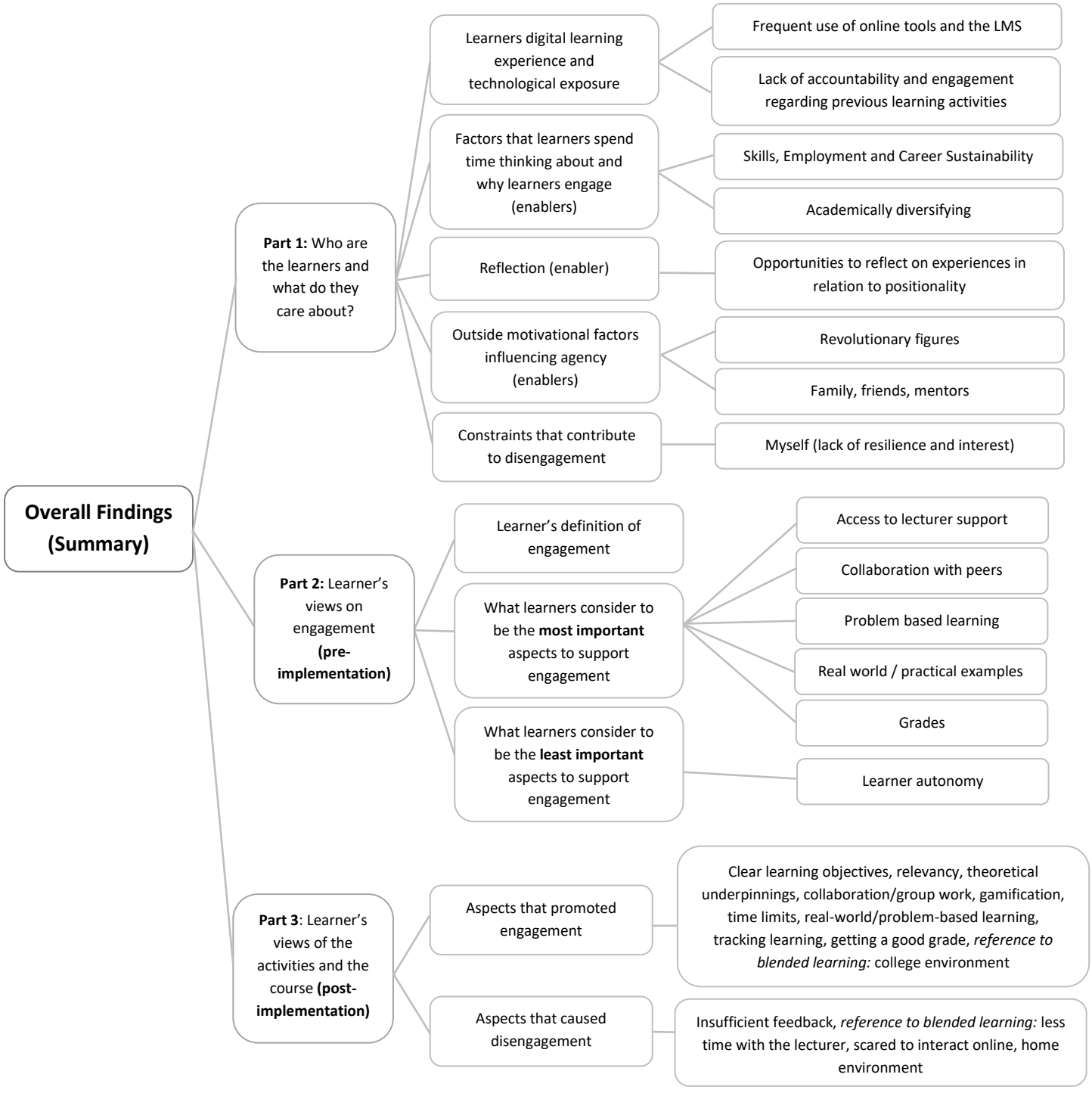


Figure 4.13: Overall Themes from the Questionnaires, Focus Group and Field Notes

Chapter 5: Discussion

5.1 Introduction

The preceding chapters laid the foundation for understanding the role of design approaches in teaching and learning algorithmic principles, and the importance of learners' agency in choosing to engage or not to engage in the learning activities. In this chapter, the focus is on analysing the findings and how they fit into the broader context of this research, investigating how learner (dis)engagement is influenced by certain enablers and constraints within a given structure and culture. By analysing and interpreting the findings, a deeper understanding of the relationship between design approaches, learner engagement, and agency in a blended learning (BL) Computer Science (CS) course is explored.

5.2 The Influence of Intentionally Designed Learning Activities on Learner Engagement

The findings of this study corroborate with the literature indicating that by utilising certain design approaches when designing learning activities, there is a positive impact on learner engagement (Quinn, 2022). From the outset the focus was the learner, placing importance on understanding and empathising with their challenges as well as their preferences. Grau and Rockett (2022) indicate that pre-course surveys highlight areas that interest learners, as well as learners' concerns. These surveys help to identify potential enablers and constraints which might explain why participants engage or disengage from the learning process. In this regard, the predesign stage of this study consisted of Questionnaire A (see Appendix A) that provided a platform for the designer to consider the learner's voice when designing the learning activities.

5.2.1 Experiences and Features of the Learning Activities Learners Find Engaging

Support

In the predesign stage of this study, participants were asked about their overall understanding of learner engagement. Their answers aligned with existing literature, confirming the importance of participative engagement (Handelsman et al., 2005; Krause, 2005). In the predesign stage many participants (75%) revealed that the learning activities which provided support and guidance from their lecturer and peers played a critical role in their engagement. This sentiment aligns with the literature indicating that perceived lecturer support has a positive influence on learner engagement (Azila-Gbettor & Abiemo, 2021). Furthermore, lecturer and system feedback were highlighted as imperative throughout the study, and participants indicated that this is an area where possible improvements could be made to the learning activities, allowing for more ongoing feedback in the design of each learning activity. Hartanto (2015) highlights the benefit of formative assessment feedback, arguing that feedback on current teaching and learning conditions provides a means for the designer to improve learning interventions on an ongoing basis, whereas the summative intention is to solely form a judgement.

Opportunities to Communicate

The learning activities that promoted collaboration and created opportunities to communicate and discuss with their peers and lecturer were beneficial for learners' engagement. This aligns with the literature indicating that collaborative learning is an effective pedagogical strategy to teach algorithmic thinking (Chetty & van der Westhuizen, 2015; Hsu, Chang & Hung, 2018). In this regard, Learning Activity 1 was designed to give learners the freedom to decide whether to work in a group or alone. More than half (59%) of the learners opted to work in a group, thus validating the preference for collaboration. The freedom to work in a group and select their group members provided a necessary level of support which contributed towards Learning Activity 1 having the highest completion rate. Whilst there were other identified factors contributing to the high rate of engagement (such as being able to select a topic of interest), participants felt that this option particularly fostered engagement. Learners who are given the opportunity to select their own group members are likely to have more open communication and are likely to gain greater benefits from the process of working in a group than learners who are assigned to a group by their educator (Chapman et al., 2006; Poort et al., 2022; William, 2011). The need for collaboration also aligned with literature indicating that collaboration is often considered valuable by learners as a factor for enhancing learner engagement (Erriska & Suyanta, 2019; Waite & Davis, 2006). Furthermore, social interaction is a fundamental component for engagement in learning activities, as the exchange of ideas promotes the negotiation of meaning with peers and educator (Cukierman, 2015; Panday-Shukla, 2023). This was echoed by several participants (63%) in the predesign stage, recognising the value of a learning environment that supports community, supporting a learner's sense of belonging and connectedness (Pelletier et al., 2023).

Selecting a Topic of Interest

Learners in this and other studies are more engaged in learning activities when given opportunities to personalise their learning experiences (Quinn, 2022; Wanner & Palmer, 2015). For example, in Learning Activity 1, several participants recognised the value of being able to select a topic of interest to problem-solve rather than being given a problem. Moreover, these topics of interest act as a means for connecting real-world applications with theoretical content, providing relevancy which increases the probability for meaningful engagement (Quinn, 2022).

A Balance between Autonomy and Heteronomy

In the predesign stage, only 31% of participants found the lecturer's promotion of autonomy (independence) helpful for engaging with the learning activities. This factor received the lowest selected percentage from participants for this question. However, participants in the focus group acknowledged the role of autonomy. Additionally, as previously stated for Learning Activity 1, more learners (59%) elected to work in a group rather than individually, suggesting a desire for less autonomy and a lean towards heteronomy, whereby learners receive guidance from

external sources. This may be due to the course being for First Year, First Semester learners and the subject content being new to most of the learners. Most participants (87%) had not taken CS in secondary school. This suggests that learners find that a balanced approach between autonomy and heteronomy promotes engagement. Learning interventions that integrate a balanced approach between structured guidance, support, and opportunities for autonomy are likely to promote a blend of independence and stability (Mercer, 2019; Panday-Shukla, 2023; Toshalis & Nakkula, 2012). Gomes and Mendes (2007) suggest that if a learner is lacking in motivation when learning programming principles, the educator should use several types of problem-solving activities of varied difficulty, starting with simplified, playful-natured learning activities entrenched in real life problems in the initial stages to attract learners, before transitioning to more demanding, complex real-world problems. This method could be adopted whereby heteronomy (structure) is provided at the beginning stages of the learning process to establish appropriate levels of motivation, before encouraging autonomy that embodies more freedom and openness.

Although it may be argued that there is a tension between heteronomy and autonomy (Candy, 1991), the two, if correctly implemented, have the potential to complement each other. This may include a structured learning activity that provides opportunities for exploration, accommodating learner independence within the learning activity structure. For example, in a BL activity in which learners are granted the opportunity to engage in content at their own pace, however in class, the educator reinforces learning through structured discussions.

Problem-Based Learning and Practical, Real-World Examples

Participants indicated that problem-based learning (PBL) entrenched in real-world, practical examples encouraged engagement with course content. Tanner, Keedy and Galis (1995) agree, indicating that PBL is entrenched in learning activities that require an active response by learners resulting in learning by doing. Additionally, PBL aided in participants determining relevancy and context, which increased the motivation to engage. This perspective corresponds with existing literature that suggests PBL serves as an effective pedagogical strategy to teach algorithmic thinking (Chetty & van der Westhuizen, 2015; Hsu, Chang & Hung, 2018; Silva et al., 2019).

Clear Learning Objectives

A high percentage (over 80%) of participants indicated the importance of accomplishing the objectives of the learning activities, stressing that having clear learning objectives was important as it gave focus and direction, providing motivation to achieve a goal. This sentiment aligns with the literature indicating that to create a truly meaningful learning experience, there need to be clear specifications of what learners need to be equipped to do because of the experience. (Pelletier et al., 2023; Quinn, 2022). Furthermore, this assists the learner in understanding the requirements and rationale for engaging in the learning activity from the beginning (Jia et al., 2023).

In relation to having clear learning objectives, participants highlighted the need to track their progress, as one participant aptly stated that being able to "feel and see" that you are capable or incapable, provides a concrete illustration of what you do know, need to know, and want to know. This level of self-awareness and self-examination speaks to the participant being cognisant of the educational journey and recognising the need to have a sense of direction and a goal. For this study, learners had the opportunity to monitor their learning progress through the learning activities on the Learning Management System (LMS), and reflect and adjust their actions accordingly. This provided a form of reflection and reflexivity which encouraged engagement, self-awareness and consideration of the learning process and the end goal (Gao, 2013; Howard, 1994). Furthermore, being able to self-reflect cultivates learner agency (Klemenčič, 2015). Klemenčič (2015) argues that learner agency becomes evident and is exercised when learners purposefully engage with someone or something, encompassing their self-involvement through critical reflection.

5.2.2 Levels of Engagement in the Learning Activities

Participants indicated that in the past they had frequently used technological tools and a LMS to complete learning activities, however there had been little accountability as they were not required to complete and submit learning activities. This was important to note, to determine (1) if a lack of exposure to online tools and an LMS should be considered by the researcher as a prohibiting factor causing disengagement; (2) other previous experiences where disengagement was occurring, for example not being required to complete and submit learning activities. Winfield and Whitelaw (forthcoming) are also in favour of this within a BL environment, ensuring that all learners have the basic resources, including a skill set, to easily access the learning activities.

Learning Activity 1

When considering levels of engagement in each learning activity, participants felt Learning Activities 1 and 3 were the most engaging. For Learning Activity 1, this corresponded with the percentage of learners that completed this activity (94%), however Learning Activity 3 had a lower completion percentage (61%). Possible reasons for the lower percentage are that learners received considerably more guided support from the lecturer and from fellow group members for Learning Activity 1. In Learning Activity 1, more time was spent by the lecturer in face-to-face lectures, explaining the requirements of the activity to learners. Furthermore, learners had the opportunity to solve a problem based on a real-world problem which they were interested in solving. In contrast, for Learning Activity 3, learners were given a real-world problem to solve but not the freedom to choose an area of interest. Lunsford (2020) supports this, indicating that having learners identify their own problem to solve encourages independent thinkers, and reduces cheating by preventing learners from simply looking for all the answers on-line or from previous learners who have completed the course.

Applying each learning activity to Handelsman et al.'s (2005) four categories of engagement, even though Learning Activity 1 exhibited elements of performance engagement, the activity consisted of elements that were particularly high in skills, and in emotional and participative/interactive engagement. For example, learners needed to apply the activity to their own lives (emotional), design certain types of algorithms (skills) and were given the freedom to work in a group (participative/interactive engagement). The mapping of Learning Activity 1 to Handelsman et al.'s (2005) four categories of learner engagement is depicted in Table 5.1.

Learning Activity 2

Participants felt this learning activity was the least engaging. This activity also scored the second lowest completion rate (67%). Bond and Bergdahl (2022) suggest that task incompletion and dislike of the task are indicators of disengagement. To this regard, participants in the focus group indicated that the design of the quiz needed to be changed, and although they recognised the importance of having a time limit for questions, they felt that there was not enough time to adequately answer each question.

Applying Handelsman et al.'s (2005) four categories of engagement, although the activity exhibited a high number of elements regarding skills and performance engagement, the activity could have consisted of more elements entrenched in emotional and participative/interactive engagement. The mapping of Learning Activity 2 to Handelsman et al.'s (2005) four categories of learner engagement is depicted in Table 5.1.

Learning Activity 3

Participants in the focus group expressed that having Learning Activity 3 based on a real-world problem required additional research, and the activity encouraged them to understand how something works on a deeper level before they could effectively implement a solution. Evidence of this level of engagement was indicated in the discussions area on the LMS. Bond and Bergdahl (2022) suggest that shared knowledge building and learners collaborating and interacting with peers are good indicators of engagement.

Another consideration was the length of the learning activity, due to the type of research that was needed, and the number of higher-order thinking questions learners were required to answer. The number and type of questions needed to be reconsidered as this activity required more time than other activities. This relates to design approaches, whereby on-going evaluations influence the design and development of the learning activity for future use, making the process iterative (Quinn, 2022).

Applying Handelsman et al.'s (2005) four categories of engagement, although the activity exhibited a high number of elements regarding skills and participative/interactive engagement, the activity could have consisted of more elements entrenched in emotional and performance engagement. The mapping of Learning Activity 3 to Handelsman et al.'s (2005) four categories of learner engagement is depicted in Table 5.1.

Learning Activity 4

Participants felt the exam-style questions simulated a final assessment, prompting them to review a large body of work, and assess their understanding prior to their formal examination. Reflecting on the field notes gathered during the implementation of Learning Activity 2, concerns around time were noted and addressed in the design of Learning Activity 4.

Applying Handelsman et al.'s (2005) four categories of engagement, this activity included a high number of elements regarding skills and performance engagement; the activity had a particularly low number of elements entrenched in emotional and participative/interactive engagement. The mapping of Learning Activity 4 to Handelsman et al.'s (2005) four categories of learner engagement is depicted in Table 5.1.

Table 5.1: Mapping each Learning Activity to Four Categories of Learner Engagement(Handelsman et al., 2005)

Number of engaging elements per category:	Low	Medium	High
Activity: 1			
Skills engagement			✓
Emotional engagement			✓
Participation/interaction engagement			✓
Performance engagement		✓	
Activity: 2			
Skills engagement			✓
Emotional engagement		✓	
Participation/interaction engagement		✓	
Performance engagement			✓
Activity: 3			
Skills engagement			✓
Emotional engagement		✓	
Participation/interaction engagement			✓
Performance engagement		✓	
Activity: 4			
Skills engagement			✓
Emotional engagement	✓		
Participation/interaction engagement	✓		
Performance engagement			✓

In broad terms, the majority of learners (77%) actively participated and completed a minimum of three out of the four learning activities, with 43% completing all four learning activities. Although a higher percentage was desired, these percentages support the suggestion that by incorporating design principles in the design and development of learning activities, it is possible to attain high levels of engagement (Quinn, 2022).

5.3 The Influence of a Blended Learning (BL) Environment on Learner Engagement

Participants indicated that a key factor which causes disengagement is the nature of online learning, discussing a preference for BL versus a fully online learning environment. This finding aligns with the literature that indicates learners prefer a BL environment rather than a full online learning approach (Nasution et al., 2021; Wanner & Palmer, 2015). Within this study, online learning was perceived as less time with the lecturer and therefore less support. Participants also expressed uncertainty on how to conduct themselves in an online learning space, with some participants indicating they were "scared" to interact online; for example, they were reluctant to ask questions in an online lecture. All the participants in the focus group felt that their home environment was not conducive to learning, as there were too many distractions, however when at college there is a psychological shift into "work mode". Moreover, in an online environment there is a lack of timely constructive feedback, and this causes disengagement. The concepts of agency, structure, and culture within a BL environment played a role in shaping individuals' actions and identities. In terms of agency, learners engaged with BL tools, participated in both face-to-face and virtual interactions, and decided when to access online resources. Structurally, the design of the BL environment was influenced by the technological infrastructure and institutional policies. Culturally, the BL environment was influenced by learners' willingness to learn from pedagogical approaches entrenched in critical thinking and problem-solving, rather than a culture that favours rote learning.

5.4 Looking Through a Social Realism (SR) Lens

The SR lens of Archer (1995, 2003, 2006) was used to explore and determine the influence of learners' agency and their actions arising from their personal concerns that cause them to either engage or disengage in the learning process. Drawing on this theoretical framework, findings in this study were compared to current theories and concepts regarding the role of agency in relation to learner engagement (Lenox, Jesse & Woratschek , 2012; National Research Council, 2003; Sentance & Csizmadia, 2017; Toshalis & Nakkula, 2012; Tyner & Petrilli, 2018).

5.4.1 The Influence of Culture, Structure and Agency on Learner Engagement

Six prominent factors were indicated by participants that caused engagement in CS theory to increase or decrease. These factors were identified as either enablers or constraints depending on the motivators or concerns of participants (Archer, 2003). Participants discussed their ultimate concerns and how those concerns they spend time thinking about influence their engagement. Participants who chose to engage in the learning activities refer to

important ultimate concerns that guided their courses of action to address that concern (Archer, 1995, 2003, 2006). In this study, this involved participants taking an active role in their learning and making meaningful choices that influenced their learning experience.

1. **Cultural Enablers: Influential Figures (Mentors)**

   Participants described the role of motivational factors such as family, friends and mentors influencing their agency and enabling the achievement of their concerns. Although participants highlighted that these influential figures were enabling, influential figures might also be detrimental and therefore be seen as constraining. Learner engagement and the learning process are intricately influenced by a range of interconnected factors such as peer relationships, social environments, family dynamics, and neighbourhood conditions. (Lenox, Jesse & Woratschek, 2012).

2. **Structural Enabler: Institutional Learning Environment**

   Structural support offered by the institution was also seen as playing a vital role for engagement. For example, the institution provided an educational setting where learners could focus and receive support from their lecturers, in contrast to their home environment, where there were too many distractions and less support available from their lecturer. All the participants in the focus group felt that the structure provided at the institution was conducive towards learning engagement, whereas their home environment presented with too many distractions. Participants noted that when they were physically at the institution there was a psychological shift into “work mode”. This acknowledgement of a mindset shift indicates the relationship between the participants’ concerns and environmental conditions, and how these aspects influence their emotional investment (Archer, 2006).

3. **Structural and Agential Enabler: Getting and Keeping a Job**

   From the interviews, a prominent concern that was identified was the need for participants to engage with their studies in order to achieve the goal of being employed. Participants expressed the need to develop skills that could lead to employment, and for those skills to facilitate career sustainability. Furthermore, they wanted their current course of action to lead to financial prosperity, which may be viewed as an ultimate concern for these learners. The participants’ responses align with current literature indicating that graduates with CS degrees have a higher probability of employment than most other sectors within economies (Business Tech, 2021; Vegas, Hansen & Fowler, 2021). This study’s findings also align with the literature regarding CS learners’ perceptions of career and employment opportunities in computing (Lenox, Jesse & Woratschek, 2012). Additionally, this indicates that participants are, to a certain degree, cognisant of their

lived reality (with South Africa currently having a high unemployment rate as of May 2024) and the need to position themselves in a field of study that has the potential for employment is imperative.

4. **Agential Enabler: Grades (Understanding the Relationship between Grades and Agency)**

   Most participants (over 80%) expressed concerns associated with obtaining a good grade and for there to be an assessment component to the learning activities, as this acts as a motivating factor. In order to encourage learners to engage and promote accountability, each of the four learning activities were assessed and had a course grade weighting of 2.5%, amounting to 10% of the course grade. Green (2015) argues that grades alone are not enough to drive learner motivation for learning, emphasising that grades function as extrinsic motivators. However, this extrinsic motivator is directly related to self-worth being entrenched in desire and fear, and this determines what is important enough for an individual to be emotionally invested in something (Archer, 2006; Richter, 2021). Using grades as a motivational factor should be carefully considered alongside intrinsic motivational factors such as having an interest in the subject. Whilst grades are an important motivator, an interest in the subject is a deeper level of motivator.

5. **Cultural and Structural Enabler: Accountability to Others Enables Agency**

   Participants expressed the feeling of accountability stemming from financial burden, and acknowledging the financial implications of them studying further. Participants indicated that their course of action is also linked to evaluating their options and making decisions based on their personal circumstances. For example, a participant shared that their father expressed that there will be no additional funds for courses to be repeated. Furthermore, if the participant does not complete their degree within three years, they would have to return home and engage in farming, a situation they wished to avoid.

6. **Agential and Cultural Constraint: A Lack of Resilience, stemming from a Lack of Interest (a Constraining Factor Constraining Agency)**

   A key challenge related to learners disengaging in the subject area of CS is the lack of resilience (Sentance & Csizmadia, 2017). Within this study, it was observed on the LMS that learners who submitted their work multiple times for feedback displayed a tendency toward perseverance, resulting in earning a higher grade. Kench, Hazelhurst and Otulaja (2016) agree, indicating that amongst South African CS learners studying programming, there is a strong correlation between a learner's perseverance and the grade they obtained. In addition, it was noted this perseverance leads learners to employ their own problem-solving strategies when they encounter problems (Kench, Hazelhurst & Otulaja; 2016).

   Although various cultural and structural aspects contributed to learner disengagement, such as: a home environment unconducive to learning, uncertainty about conduct during synchronous lectures, a lack of

timely constructive feedback online, and high travel costs preventing attendance at face-to-face lectures, several participants expressed that their internal motivation was one of the most influential factors contributing to their disengagement. They stressed that personal motivation is key, for example being interested in the subject, and making time to engage with the content. When an individual possesses a genuine interest, the desire to be engaged in a particular learning activity increases for an extended duration (Harackiewicz, Smith & Priniski, 2016). The pedagogical experiment of Reggio Emilia highlights the positive influential approach of allowing learning interventions to emerge based on the interests and questions of the learner (Rinaldi, 2021). An interest in the field of study is a necessity as it is rooted in intrinsic motivation and having a sense of self (Archer, 2003, 2010; Quinn, 2022).

Learners determine what is worth investing in based on what really matters to them (Archer 2003, 2010). In other words, if the participant has a sense of self within the learning activity and there are degrees of freedom within the social structure (the learning activity), then there will be an increased desire to engage. Quinn (2002) reiterates this sentiment, by designing interventions that promote and reinforce what the learners care about, and on a deeper level incites a reason to commit to the effort and maintain (sustain) that commitment throughout the learning process. In turn, the commitment is not merely a snapshot of engagement that would represent trivial fun, as often seen with approaches such as gamification interventions that have a high entertainment level. This is a shift from learner engagement being represented as a moment in time to a long term, deep level, form of meaningful engagement that will extend beyond the boundaries of the course. In addition, this freedom to explore an individual interest within the learning context allows for the cultivation of intrinsic motivation (Panday-Shukla, 2023; Quinn, 2022; Richter, 2021). Bowden (2022) supports this, indicating that emotional engagement in a BL environment contributes to learner's self-awareness, problem-solving skills and agency that ultimately leads to self-empowerment.

5.5 The Relationship Between Design Approaches, Learner Engagement and Agency in a Blended Learning (BL) Course

The Relationship between Design Approaches and Learner Engagement

Using design approaches within this study facilitated a learner-centric approach to designing and developing learning interventions that embody elements that influence learner engagement (Quinn, 2022). The findings from this study, which indicate the effectiveness of using real-world problems and authentic contexts to enhance learner engagement, are consistent with those of other studies that have used this approach as a pedagogical strategy to teach algorithmic design (e.g., Chetty & van der Westhuizen, 2015; Gulatee & Combes, 2006; Hsu, Chang & Hung, 2018; Silva et al., 2019).

Moreover, the beneficial impacts of design approaches on learner engagement align with the findings of Quinn's (2022) research on the effects of specific design approaches on learner engagement. For example, to foster learner engagement in a learning activity, the design must extend beyond reliance on extrinsic motivation (Quinn, 2022).

The Relationship between Design Approaches and Learner Agency

The design approach of 'diverging and converging' adopted in the creation of the learning activities, enabled the designer (the researcher) to generate ideas for designing the learning activities before evaluating them too soon. When learners feel that their input matters, and that they have a role in shaping their learning experiences, they are more likely to be actively engaged in the learning process taking action to align with their ultimate concerns. Having a design approach that had clear learning outcomes (goals), combined with learning activities that were of interest promoted engagement. This emphasises that learners choose what to invest in, based on what really matters to them (Archer 2003, 2010).

The Relationship between Structure, Culture, Agency, and Meaningful Engagement

In this study, six key enablers and constraints related to learner engagement were identified, highlighting the complex interplay of agency, structure, and culture. Prominent enablers identified were influential figures, the institutional learning environment, employment prospects, accountability established by the educational institution (through assessment criteria), and a desire for good grades. A prominent constraint identified by participants was themselves and whether they manifested a lack of resilience which could have stemmed from a lack of interest.

This study, supported by literature, indicated that allowing learners to make choices within learning activities provides them with agency and this increases their engagement (Grau & Rockett, 2022; Reeve & Tseng, 2011). Moreover, within a learning computation thinking context, Li et al. (2023) stress that when learners' emotional engagements are elevated, the positive relationships between cognitive engagement, computational thinking, and creative thinking become increasingly closer.

The Relationship between Blended Learning (BL) Environments and Learner Engagement

The relationship between BL and learner engagement can vary based on several factors. Participants found a BL environment beneficial for engagement. However, some expressed concerns around online synchronous learning, such as lacking the confidence to ask questions during online lessons and not being able to work from home due to too many distractions, which resulted in a decrease in motivation and accountability. This speaks of structural constraints experienced by participants that caused disengagement.

Participants ultimately stressed that 100% online learning results in disengagement, and that a blended approach to learning creates a healthier balance. However, an appropriate split of online and face-to-face needs to be applied, incorporating social elements into BL strategies to promote engagement (Allen & Seaman, 2016; Wenmoth, Jones &

DiMartino, 2021). This approach is suited to the teaching of algorithmic design, as it can facilitate collaboration beyond the classroom via online platforms and communities, but also recognises the essential role of face-to-face classes for immediate feedback and personal interaction (Förster et al., 2021).

Overall Relationship

The best way to engage learners is to encourage learners to take an active part in the learning process (Grau & Rockett, 2022; Wenmoth, Jones & DiMartino, 2021). Design approaches contributed to providing a voice for learners in the design and development of the learning activities. Through this voice, meaningful engagement was promoted when creating learner-centric learning activities. This engagement empowered learners to assume active roles in their learning, thereby influencing their agency. Being cognisant of the relations between design approaches, individual agency, and meaningful learner engagement facilitated this learning process. Furthermore, in a BL environment, the design approach impacts the extent to which learners can exercise their agency as it has the potential to determine how much control and flexibility they have over their learning process.

5.6 The Meaningful Engagement (ME) Framework (developed by the author)

At the heart of this study is meaningful engagement (ME), the time and energy a learner devotes to a learning activity by using technologies and practices to assist in solving a problem in a BL environment. The ME framework aims to encourage not just engagement on a superficial level, but engagement that fosters internal intrinsic motivation which ultimately leads to self-empowerment.

Within the focus of this study, investigating the learner's needs, challenges, and preferences determined which key technologies and BL pedagogies to consider when designing each learning activity. For example, with reference to Figure 5.1, in Learning Activity 1 Microsoft Visio (online version) was used as a key technology and group work (pedagogy) within a BL environment. These were chosen because Microsoft Visio is free, supports algorithm design, allows real-time collaboration, is user-friendly, and integrates with Microsoft OneDrive for cloud storage. This key technology facilitated group work (pedagogy) in a BL environment.

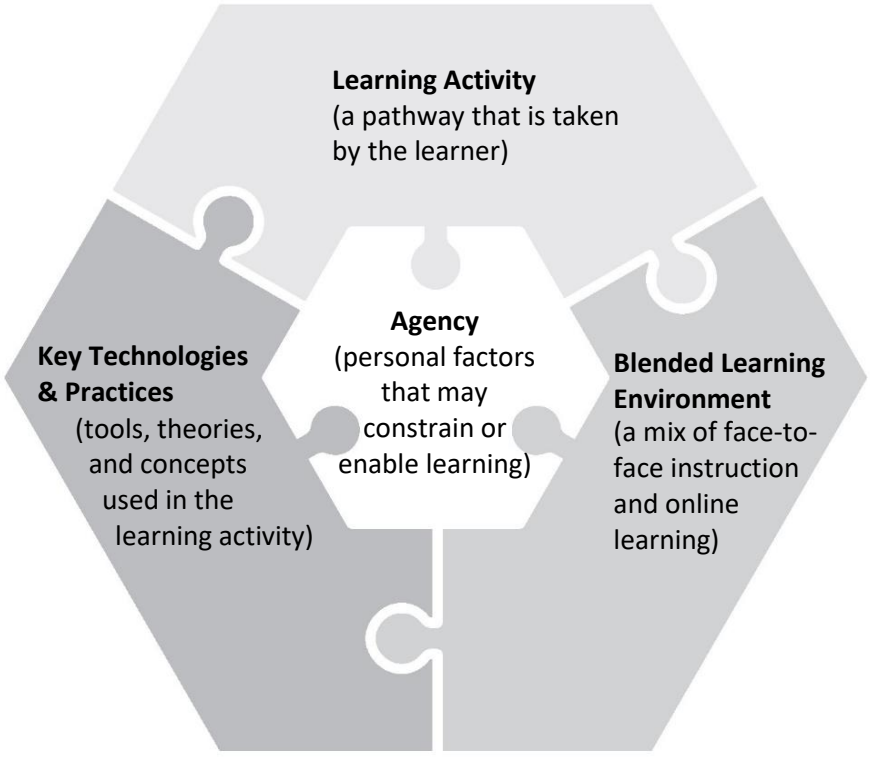
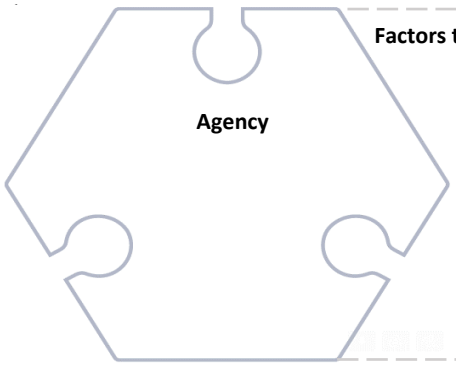


Figure 5.1: The ME Framework

The puzzle pieces that make up the Meaningful Engagement framework represent the complexity of designing and developing learning activities for meaningful engagement. At the centre of the four-piece puzzle is Piece 1 (Figure 5.2), Agency. This piece sets out to investigate who the learners are, and considers factors that promote agency. It highlights the need for practitioners (often educators) to gather feedback from learners and adapt their teaching methods and designs of learning activities based on these insights. A design approach is recommended in which

divergent thinking (expanding possibilities) will assist in analysing who the learners are (empathising). Therefore, the first piece of the puzzle involves uncovering concerns: who are the learners? What do they care about? What are their pain points? What enables and/or constrains their learning? These are factors to consider when attempting to design and develop a learning activity that gives thought to meaningful engagement, as represented in Figure 5.2.

Who are the Learners and What Do They Care About?



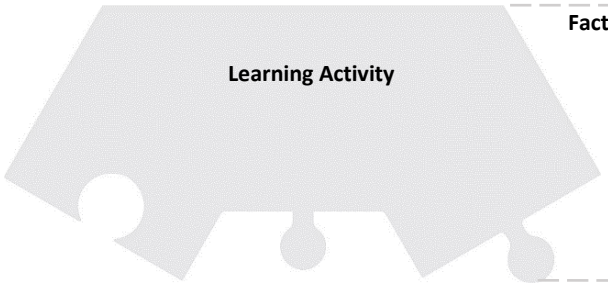
Factors to consider:

- Learner's interest level in the subject
- Home and institutional environment (conducive to learning?)
- Foundational skill set (hard and soft skills?)
- Influential figures (mentors and/or detrimental figures)
- Support at the beginning and continued throughout (scheduled learner support?)
- Opportunities for reflection
- Balance of learner autonomy and heteronomy
- Time management (weekly/activity tracker and badges)
- Accountability (each activity has a percentage of the course mark e.g., 5%)
- Sufficient and timely feedback

Figure 5.2: Piece 1 of the ME Framework

Piece 2 considers what sort of learning activity the educator is interested in designing and developing, and the learning objectives (outcomes of the learning activity). This involves a design approach of convergent thinking, narrowing down and selecting possible ideas. This is achieved by considering the content to be taught (outcomes), the defined problem statements stemming from what the learners care about (Puzzle Piece 1) and the additional factors indicated in Figure 5.3. Moreover, this piece considers whether these factors will promote meaningful engagement.

What Type of Learning Activity Do I Wish to Create?



Factors to consider:

- Clear learning objectives (content), match the learning outcomes to Blooms Taxonomy
- Relevancy
- Scaffolding
- Duration
- Opportunities for learners to personalise their learning (e.g., selecting an area of interest)
- How will the learning activity be assessed? (mark allocation)

Figure 5.3: Piece 2 of the ME Framework

Piece 3 looks at potential practices to be used in the learning activity, for example appropriate strategies (overall plan) and teaching methods (pedagogy) for achieving this plan, as well as selecting the type of technology to be used by learners to achieve the learning outcomes. Moreover, this piece also considers whether these factors will promote meaningful engagement, as indicated in Figure 5.4.

What Key Technologies and Practices Do I Wish to Use in the Learning Activity?

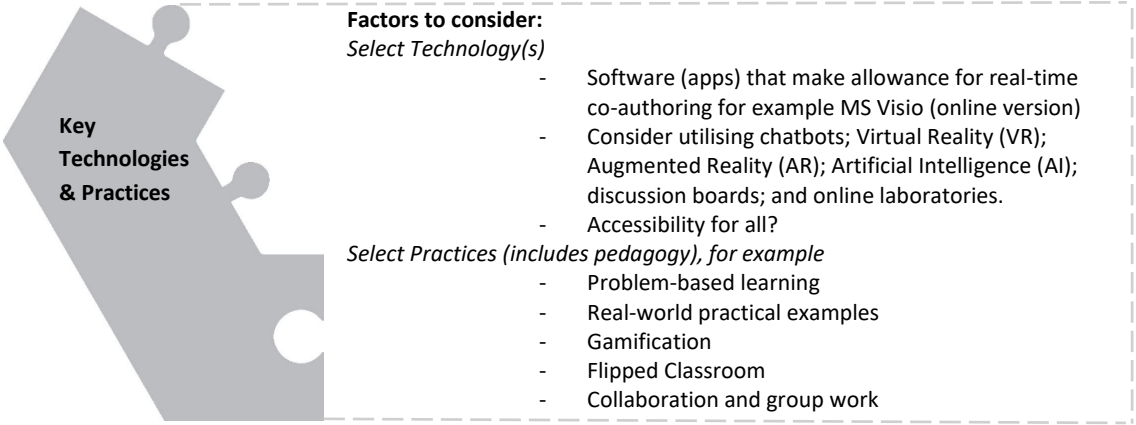


Figure 5.4: Piece 3 of the ME Framework

The fourth and last piece of the puzzle, Piece 4, looks at the potential for adopting a BL approach in relation to the learning activity and the chosen key technologies and practices. This involves uncovering how online and face-to-face components will complement each other. Moreover, this piece also considers whether these factors will promote meaningful engagement, as indicated in Figure 5.5.

Does the Activity Lend Itself to a Blended Learning Environment?

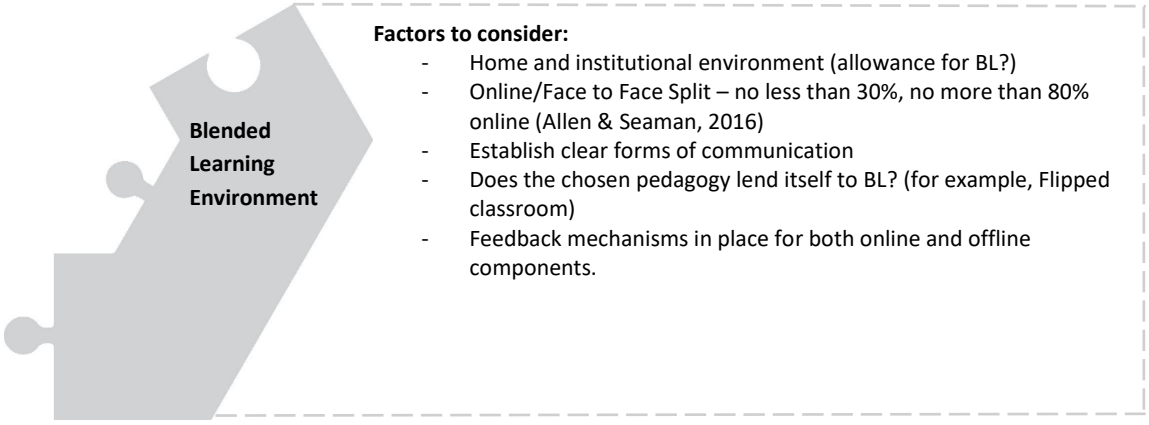


Figure 5.5: Piece 4 of the ME Framework

By using these four pieces to assemble the puzzle, practitioners should have a clearer picture when prototyping, testing, and assessing their learning activity. The aim of using the ME framework is to create a learning activity that motivates change, transforming a learning experience (learning activity) where there are high levels of disengagement amongst learners, to a more enriching, engaging experience. Whilst the argument may be made that careful consideration and implementation of each factor is impractical, this framework suggests that dependent on the context, the depth of analysis and whether it is implemented will differ for each factor.

The ME framework may also be used as a framework for characterising learner experiences with the learning activity. The ME framework can be used as an analytical tool to determine why a specific learner is disengaging from a learning activity. This could be achieved by considering the factors indicated in each puzzle piece.

5.7 Summary

By analysing the data from the findings and literature, this chapter focused on uncovering the factors that influence the relationship between design approaches, agency, and BL environments that support the creation of learning activities for meaningful engagement. Furthermore, the interconnectedness of these factors resulted in the creation of the ME framework which encourages practitioners to consider numerous aspects of learning (e.g., learner agency) in relation to meaningful engagement.

Chapter 6: Conclusion and Recommendations

6.1 Introduction

This study set out to understand why learners were disengaging and under-achieving in the subject area of algorithmic design in Computer Science (CS). Therefore, the objective of this study was to establish how to achieve meaningful engagement in a CS first-year tertiary course. This study set out to understand learner engagement (and a lack thereof), to explore this using a Social Realism (SR) framework, and develop a model that could be used by educators with a focus on meaningful engagement. This study concludes that for meaningful engagement to occur, certain cultural, structural and agency enablers need to be in place. Furthermore, by designing interventions that promote and reinforce what the learners care about, encourages, on a deeper level, a reason for the learner to commit to the effort and maintain (sustain) that commitment throughout the learning process. This commitment is not merely a snapshot of engagement, it is a fundamental shift from learner engagement being represented as a moment in time, to a long term, deep level form of meaningful engagement that will extend beyond the boundaries of the course.

6.2 Response to the Research Questions

This section is a response to the RQs (primary and secondary RQs) as indicated in Section 1.5 of Chapter 1. The primary research question explored the relationship between design approaches, meaningful engagement, and agency in a blended learning CS theory course. The secondary RQs investigated the impact of design approaches on meaningful engagement, identified (dis)engaging features of learning activities from learners' perspectives, explored cultural and structural factors influencing (dis)engagement, and examined how learner agency affects meaningful engagement in the course.

6.2.1 Learner Informed Design Increases Engagement

Certain design approaches adopted in this study had an impact on engagement. By prioritising the learner and understanding their challenges in the beginning stages of design process, aided in the creation of user-centric learning activities, provided a voice to learners in the design. Learners are more engaged in learning activities when given opportunities to personalise their learning experiences (Cordova & Lepper, 1996; Wanner & Palmer, 2015). For example, enabling learners to explore topics of interest encourages a connection between real-world applications and theoretical content, providing relevancy which increases the probability for meaningful engagement.

6.2.2 A Multifaceted Approach to Designing Learning Activities for Engagement

Participants highlighted certain approaches that facilitated engagement. The role of support was emphasised by participants, which indicated the desire for guidance from lecturers and peers. Opportunities for collaboration were

deemed to be important and learning activities that embodied aspects of communication amongst peers were valued. Selecting a topic of interest (personalisation) was identified as a key factor for meaningful engagement, aligning the value of intrinsic motivation with the literature. The balance between autonomy and heteronomy was discussed by participants, acknowledging the role of both in promoting engagement. Problem-based learning (PBL) and real-world practical examples were identified as effective, encouraging active participation and relevance. Clear learning objectives were seen as critical, and the ability to track progress to determine if these goals (objectives) were being achieved provided awareness and focus. These six factors: support, communication, personalisation, autonomy-heteronomy balance, PBL, and clear objectives, indicate the multifaceted approach needed when creating learning activities for meaningful engagement.

6.2.3 Resistance to Blended Learning can be a Cause of Disengagement

Participants indicated disengagement in online learning, preferring blended learning (BL) over fully online formats. Moreover, concerns associated with fear to communicate online, lack of timely feedback and home distractions were seen as contributing factors for disengagement. To a certain extent this was expected, teaching CS at both a tertiary college and a secondary school in 2020 gave me valuable insights into the challenges associated with remote learning during the COVID-19 pandemic. It is important to take into account learners' resistance to studying in a BL environment when designing learning activities, as this indicates an awareness of their needs. Designing activities that promote collaboration will assist in addressing the challenge of maintaining a sense of community when learners are online. Furthermore, clear expectations and feedback is needed to provide structure and accountability to the flexibility a BL environment offers.

6.2.4 Theoretical Contribution: The Importance of Understanding Culture, Structure, and Agency

In the surveys and focus group, learners identified enablers and constraints in their contexts. These enabling and constraining factors have been separated analytically into cultural, structural, and agential factors.

Cultural Factors: influential figures, for example family members, friends, mentors, and revolutionary figures played a crucial role in influencing learners' agency.

Structural Factors: the institutional learning environment as a structural support contrasted with the home environment, where there are too many distractions resulting in disengagement. For example, accountability due to financial constraints was seen as an influential factor for increased engagement.

Agential Factors: participants emphasised the need to engage in their studies for future employment, career sustainability, and financial prosperity. Obtaining a good grade was seen as a motivating factor. Moreover, the relationship between grades as an extrinsic motivator and being genuinely interested in the subject as an intrinsic

motivator was discussed. Lack of resilience stemming from a lack of genuine interest was highlighted as a constraint, indicating the relationship between perseverance, and obtaining a good grade.

Participants discussed ultimate concerns, indicating the role these concerns play in guiding their engagement. Agency was seen as being an influential aspect of learner engagement, providing a process through which learners take action to enhance their learning experiences and the environments in which they learn. The interviews revealed that unless these ultimate concerns are addressed, disengagement will occur.

6.3 Implications of the Research

The low uptake and throughput rate of learners graduating from CS courses in South Africa, warranted a deeper understanding of the learner, and why learners engage or disengage when studying algorithmic design, an area learners find difficult. The aim of this study therefore involved trying to understand the relationship between activity design, agency, and learner engagement within the context of creating learning activities in a BL CS theory course. It was noted from the literature review that consideration of agency has the potential to have a positive influence on learner engagement, not simply a snapshot of learner engagement, but a long term, deep level form of meaningful engagement that would extend beyond the boundaries of the course. In this study, the argument was made with regard to the critical role that certain key factors (enablers and constraints) play in this process. The results presented here come at a time when studies of this sort are useful for creating learner-centric interventions that foster meaningful engagement in a technology-driven BL environment.

Prior to undertaking this study, my understanding of (dis)engagement was rather generalised. However, use of the SR theory uncovered an additional layer of complexity, which made allowance for (dis)engagement to be perceived in a new light. Whilst conducting this study, it became apparent that this is an intricate endeavour consisting of an array of factors. As a result, to assist practitioners in considering the numerous aspects that form the relationship between design approaches, agency, and meaningful engagement when creating learning activities in a BL environment, the ME framework was developed.

6.4 Study Limitations

This study has some limitations, such as a small sample size, and the study being conducted within a single institution. Nevertheless, an in-depth approach consisting of mixed methods research, was necessary to gain a detailed understanding of enablers and constraints associated with learner (dis)engagement within the context of the study.

From the findings, there were suggestions of contradictions such as participants in the predesign stage indicating a desire for less autonomy, with an inclination towards heteronomy, yet the focus group highlighted the importance

of learner autonomy. Further research could lead to learning designers adopting a balance between autonomy and heteronomy within their learning interventions.

6.5 Recommendations

It is suggested that the educator collaborate with the learner, the learning designer (if not the educator), and management to achieve these recommendations.

Recommendation 1: Get To Know Your Learners

Allocate time to determine the needs and pain points of the learners and in so doing, consider factors such as age, life histories, prior knowledge, and preferred learning styles. Adopting certain design approaches such as promoting divergent thinking and uncovering concerns, having clear learning outcomes, and utilising problem-based learning (PBL) will facilitate this process. This provides a platform for the learning designer (often the educator) to create educational experiences (i.e., learning activities) that resonate with a learner's context, empowering learners to invest in what truly matters to them and forge a path of sustained engagement within the learning process. This will enable learners to cultivate a commitment that transcends mere momentary interest. This shift from transient engagement to meaningful engagement fosters intrinsic motivation, driving learners towards self-awareness, problem-solving skills, and agency.

Recommendation 2: Design for Support

In this study, the learner's relationship with their lecturer and peers was identified as being an essential ingredient for learner engagement. Moreover, participants indicated that knowing how and where to get help was fundamental for engagement. To this regard, the following is suggested: (1) set clear learning objectives that are measurable, providing direction to learners; (2) design for accessibility, catering for a diverse range of learners with different learning styles; (3) design for collaboration (i.e., discussion boards, group learning activities); (4) promote accountability through on-going assessments, and determine from the results where learners need additional support; (5) design for timely constructive feedback; (6) use technology thoughtfully (i.e., LMS, interactive tools, chatbots, AI) to foster meaningful engagement; (7) apply iteration (design principles) to continuously improve learning interventions; and (8) timetable for support, each week (at the beginning and throughout the semester).

Recommendation 3: Design for Meaningful Engagement

When creating learning activities, consider using the ME framework, which encourages practitioners to be mindful of contributing factors that foster meaningful engagement. For example, giving learners the freedom to pursue the solution to a problem of interest within a learning activity. This pursuit of interest allows for the cultivation of intrinsic motivation (Panday-Shukla, 2023; Quinn, 2022; Richter, 2021). The ME framework was designed to be versatile and

may also be used to contextualise a specific learner's situation to determine why engagement or disengagement is occurring in the learning process i.e., the learning activity.

Recommendation 4: Design for Social Interaction in a Blended Learning Environment

Substituting face-to-face learning with BL may result in a loss of social interaction, therefore social elements should be considered when designing and developing BL interventions (Mali & Lim, 2021). Winfield and Whitelaw (forthcoming) echo this sentiment, stressing the importance of support and collaboration within a BL environment, indicating that BL interventions should consider using guidance and structure to assist learners with time management. Furthermore, group work should be considered to reduce the psychological distance between learners. Winfield and Whitelaw (forthcoming) promote the use of regular knowledge checks and weekly online videos. They also encourage the use of online analytics to create reward structures that increase motivation, such as awarding a badge after the completion of each learning activity. This will promote a set of behaviours that strengthen a commitment to the learning process (Quinn, 2022). Allen and Seaman (2016) suggest that a true BL environment is a split of online and face-to-face with no less than 30% and no more than 80% online.

6.6 Future Research

This study was conducted within a private tertiary institution with the sample of participants consisting of First Year CS learners. It is not yet clear how the relationship between design approaches, learner engagement and learner agency may change in different settings such as learners of a different subject, ethnic and cultural backgrounds, academic level, government institution and so on.

Archer's analytical dualism, which separates culture, structure, and agency for analytical purposes, allows researchers to identify specific factors within each domain that contribute to learner engagement. The identified enablers and constraints within this study highlighted certain underlying mechanisms that drive learner (dis)engagement. These mechanisms could be tested on other samples to further understand the depth of these influences on learner engagement.

Future research into the use of the ME framework would build on the findings of this dissertation, testing the potential impact of implementing the suggested key factors. For example, one could subdivide learners into different groups, where one group is required to participate in certain learning activities (learning activities designed using the ME framework) and the other, acting as a control group, does not. To ensure ethical compliance and mitigate potential disadvantages for the control group, those not receiving the intervention could be offered it at a later stage if their performance did not improve. Furthermore, the ME framework has the potential to be used as an analysis (research) tool by educators to determine why a learner is (dis)engaging in a learning process i.e., the learning activity.

6.7 Final Word

The need to promote computer science education (CSE) in South Africa is essential in addressing the high unemployment rate, particularly amongst the youth. However, the low throughput rate from high school to tertiary education, and the considerably lower graduation rate speaks to the challenges experienced by CS learners. On a fundamental level, an identified challenge learners struggle with is designing algorithms, with disengagement being of concern. Therefore, in this study the researcher sought to understand the relationship between design approaches, meaningful learner engagement, and learner agency in a blended learning Computer Science course.

Incorporating Archer's theoretical framework revealed that the relationship between design approaches, meaningful engagement, and personal agency is complex and deeply interconnected with an individual's structural and cultural environment. This study supports Archer's theory, indicating that structural and cultural factors can either facilitate or hinder the realisation of personal projects within an educational context. Furthermore, this study highlighted that allowing learners the freedom to explore their individual interests within learning activities enhances engagement, fostering long-term, meaningful involvement. Designing learning activities that embody learner agency encourages active participation, and engaged learners are more likely to develop a sense of agency in their learning.

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Appendices

Appendix A: Questionnaire A (Predesign)

(PLEASE NOTE: participants needed to complete Appendix J: Consent Form, before completing this questionnaire)

1. How would you define learner engagement?

_____

_____

_____

2. What would you consider to be the BEST ASPECTS of how learning activities engage learners? Please provide an example of a time when you felt engaged in a learning activity.

_____

_____

_____

3. What has been the most important factor contributing to your learning and development at college and please explain why it is important.

_____

_____

_____

Please place a ✓ in the relevant box(s).

4	**During the past and current academic year, about how often have you done the following?**						
		0	1-5	6-10	11-15	16-20	More than 20 hours
a)	Preparing for class (e.g. reading, doing homework, etc.).						
b)	Attending timetabled activities (e.g. lectures etc.).						
c)	Participating in online activities (e.g. online lectures, discussion forums, etc.).						

5	During the past and current academic year, about how often have you done the following?				
		Never	Sometimes	Often	Very Often
a)	Discovered supplementary information to aid in understanding subject activities and assignments when the material was unclear.				
b)	Engaged in subject discussions, even during times when motivation was lacking.				
c)	Completed a task that you started despite facing obstacles along the way.				

6	In general, to what extent have your digital learning experience:					
		Very little	Some	Quite a bit	Very much	Not applicable
a)	Offered activities that prompt you to interact with the content in a critical manner.					
b)	Structured activities to allow for a suitable timeframe to finish them.					
c)	Offered guidance using language that was easily understandable for you to follow.					
d)	Required the completion and submission of learning activities.					

7	When working through a learning activity, do you prefer:		
		Yes	No
a)	That content is divided into small “learning nuggets”, don’t put too much content on one page.		
b)	To be assessed after each learning activity/task.		
c)	To be provided with lecturer feedback after each learning activity/task.		
d)	To draw pictures/diagrams to clarify course content.		
e)	To combine current concepts with previous course content.		
f)	To be required to complete and submit activities and assignments.		

8	When completing a learning activity what features do you find helpful:					
		Very little	Some	Quite a bit	Very much	Not applicable
a)	External websites that support learning (e.g., YouTube videos, etc.).					
b)	Online tools (e.g., email, applications, etc.).					
c)	School/College learning platforms (e.g., Google Classroom, Learning Management System (LMS), library resources, etc.).					

9	Which of the following do you find particularly helpful when engaging with course content (you may select more than one):	
		Please place a ✓ in the relevant box(s).
a)	Clear learning goals	
b)	Gamified learning activities i.e., having an anonymous scoreboard in an eLearning game.	
c)	Continuous feedback by your lecturer	
d)	Your lecturer promoting learner autonomy (independence)	
e)	Rubrics that provide frequent and useful feedback	
f)	Creating a learning environment that supports community	
g)	Involve all learners in discussion	
h)	The incorporation of games	
i)	A graphical syllabus (less reading)	
j)	Problem based learning	
k)	Case Studies	
l)	Opportunities to reflect on your learning	
m)	Knowing how and where to get help	
n)	A course/module online progress bar	
o)	Opportunities to communicate with other learners	

10. Please indicate your age:

11. What is your gender identity?

Male	
Female	
Another gender identity	
I prefer not to respond	

12. What is your home language or mother tongue? (Mark all that apply)

Afrikaans	
English	
IsiNdebele	
IsiXhosa	
IsiZulu	
North Sotho	
Sesotho	
Setswana	
SiSwati	
Tshivenda	
Xitsonga	
Other	

13. As a learner, generally, in which category do most of your marks fall?

0-39%	
40-49%h	
50-59%	
60-69%	
70-79%	
80-89%	
90-100%	

14. Did you take any of the following subjects in Grade 12?

Computer Application Technology (CAT)	
Information Technology (IT)	
None of the above	

Appendix B: Questionnaire B (at the end of the course and the four learning activities)

(PLEASE NOTE: participants needed to complete Appendix J: Consent Form, before completing this questionnaire)

Section A: Learning Activity Engagement

When working through the four learning activities, how well do the following behaviours, thoughts, and feelings describe you?

Please answer using the following scale (Place a ✓ in response to each item):

1. Strongly disagree
2. Disagree
3. Neither agree/nor disagree
4. Agree
5. Strongly agree

No		Question/Statement	1	2	3	4	5
1	a)	When completing the activities, I try to relate what I am learning to what I already know.					
	b)	The activities stimulated my learning.					
	c)	The learning activity objectives were clear to me.					
	d)	When completing the activities, I try to connect what I am learning with my own experiences.					
	e)	Interactive multimedia was essential in the learning activity.					
	f)	The activities gave me sufficient feedback.					
	g)	The difficulty level of the activities was appropriate.					
	h)	The pace of the activities was appropriate.					
	i)	I accomplished the objectives of the activities.					
	j)	I will be able to use what I learnt from completing the activities.					
	k)	The activities were a good way for me to learn content.					
	l)	When I worked through the activities, I felt curious about what I was learning.					
	m)	There was a feeling that I was involved in the activities.					

2	**Indicate which learning activity you engaged with the most by ranking each learning activity from 1 to 4 (1 being the learning activity you engaged with the most and 4 being the least)**	
		Rank (1 – 4)
a)	Learning activity 1 – *(Designing and developing an IPO table, Flowchart and Pseudocode in Microsoft Visio)*	
b)	Learning activity 2 – *(Gamified quiz)*	
c)	Learning activity 3 – *(Interacting and contributing to the discussion board)*	
d)	Learning activity 4 – *(Research and then completing the test on Arrays)*	

3. What did you ENJOY MOST when engaging with the learning activity?

_____

_____

_____

_____

_____

4. What did you ENJOY LEAST when engaging with the learning activity?

_____

_____

_____

_____

_____

5. How would you improve the learning activity(s)?

_____

_____

_____

_____

_____

Section B: Course Engagement

Within the course, how well do the following behaviours, thoughts, and feelings describe you?

Please answer using the following scale (Place a ✓ in response to each item):

1. not at all characteristic of me

2. not really characteristic of me

3. moderately characteristic of me

4. characteristic of me

5. very characteristic of me

No		Question/Statement	1	2	3	4	5
6	a)	Making sure to study on a regular basis.					
	b)	Putting effort into your studies.					
	c)	Keeping up to date with your readings.					
	d)	Looking over class notes (between lectures) to make sure I understand the material.					
	e)	Being organised.					
	f)	Taking good notes from readings, PowerPoints, or video lectures.					
	g)	Listening/reading carefully.					
	h)	Finding ways to make the course material relevant to my life.					
	i)	Applying course material to my life.					
	j)	Finding ways to make the course interesting to me.					
	k)	Really desiring to learn the material.					
	l)	Engaging with online chats, discussions or via email with the instructor or other learners.					
	m)	Participating actively in small-group discussion forums.					
	n)	Helping fellow learners.					
	o)	Getting a good grade.					

Appendix C: Focus Group Interview Questions

(PLEASE NOTE: participants needed to complete Appendix J: Consent Form, before completing this questionnaire)

PART A – Learning Activity Related

1. Whilst working through the learning activities, did you find that your learning engagement increased, decreased, or stayed the same?
    - If it decreased or increased, can you explain why? Are the reasons related to your personal motivation?
    - Was the increase or decrease in engagement related to contextual issues outside of the classroom?
2. Considering the four learning activities, which features in the learning activities do you believe assisted you the most in engaging with the course content?
3. When working through a learning activity what motivates you to research the topic more?

PART B – Course Related

4. Why do you think some learners may become disengaged when learning Computer Science theory in a blended learning environment?
5. What did you find most valuable about this course?

PART C – Agency Related

6. Can you describe your life goals and concerns that you would like to achieve and address over the next few years?
7. How much time do you spend thinking about what you should do to address these concerns?
8. Have you noticed anything in your background which is helpful or obstructive in relation to your concerns? Were there any outside influences, be it your peers, family, and/or infrastructure (such as access to technology - the internet, LMS) that contributed to your engagement or created barriers when engaging in the course?
9. Will studying Computer Science help you to achieve your goals and address your concerns?

Appendix D: The Four Learning Activities (Outcomes, Features, and Learner Instructions)

In **Activity 1** learners needed to design and develop an IPO (input, processing output) table, flowchart, and pseudocode in Microsoft Visio. The outcomes of the learning activity were to:

- Identify a real-world problem.
- Create various types of algorithms (IPO table, flowchart, and pseudocode) to address the problem.

The following instructions were given to learners:

Working in groups of 2 or 3 (no more than 3)

Step 1:

Identify a problem that you and your group member(s) would like to design a solution for and provide a summary describing the problem. This section needs to contain a description of the problem area you are trying to address. It should encompass all aspects of the problem. Place this paragraph in a text box on the first page of the Visio document. You are to create the following in your group:

•Problem Definition (Page 1 in Visio)

Remember to place your name(s) and learner Number(s) of your group members in the top left corner, i.e.: John Smith - 123123123, Peter Botha - 321321321

Step 2:

Detail the actual design elements of the program, namely: program flow (how the program works).

You are to create the following in your group:

•IPO table (Page 2 in Visio)

•A flowchart (page 3 in Visio)

•Pseudocode (page 4 in Visio)

Your design must make use of the following elements/structures: variables and constants, methods, all three basic structures, that being: sequence structure, selection structure and looping structure (you may decide how many times you would like to use each).

An example of requirements is in Lecture 12 PowerPoint presentation.

Once you have completed your learning activity, provide the link to your groups (shared) Visio Link by clicking on the learning activity title in the LMS and submitting the link.

Activity 1 had a strong focus on create, however, to effectively achieve the higher order skills of create, the other levels of cognition needed to be achieved at varied depth. To achieve the learning outcomes learners needed to have achieved lower order thinking such as remember, understand, and apply before progressing onto higher order thinking such as analyse, evaluate, and create.

In **Activity 2** a web-based gamified quiz was designed in Quizizz for learners to engage with. Using Quizizz encourages interactivity between the players and the quiz, which increases motivational levels and assists in improving understanding (Rahayu & Purnawarman, 2019). The outcomes of the learning activity were to:

- Revise the following: elements of high-quality programs and algorithmic structure.
- Interact and complete the gamified quiz.

The following instructions were given to learners:

> STEP 1: Revise
> Chapter 1 - 5: Spend some time revising these chapters. It will be helpful to create summaries on each chapter before completing the gamified online quiz.
> STEP 2: Complete the Gamified Quiz
> Make sure to enter in your name and surname before you begin. This will be used to record that you have completed the learning activity. Link to the Quiz: https://quizizz.com/join?gc=13454261

With reference to Bloom's Taxonomy, this learning activity was particularly entrenched in evaluate. Screenshots of the different aspects of the learning activity are described below.

The quiz was one hour long and consisted of 20 questions. The question order was randomized for each learner.

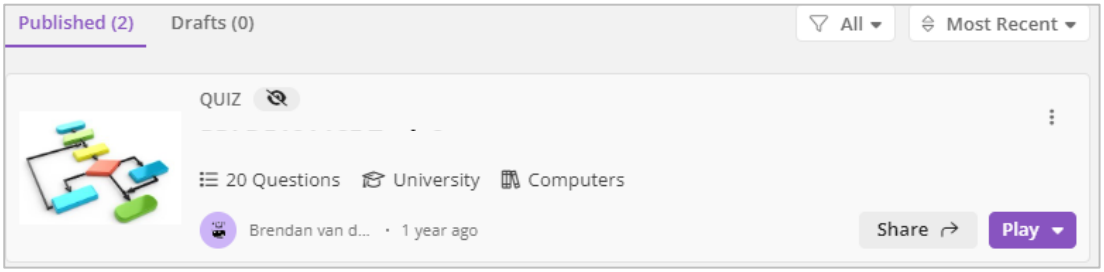


Figure D1: Creating a Quiz in Quizizz

A timer, memes and power-ups were used for each question to promote engagement. Other features included were gamified sound effects.

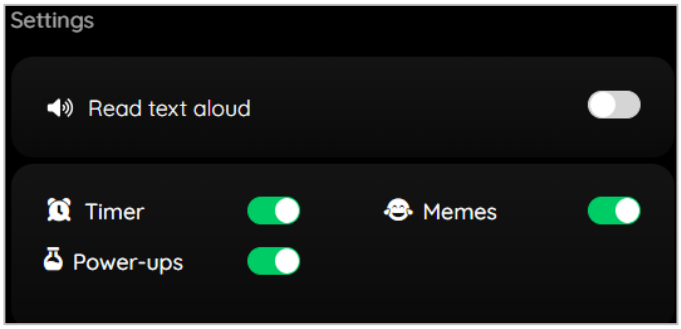


Figure D2: Quizizz Settings

Having time constraints on each question encouraged learners to stay focused and to avoid distractions. Additionally, this assisted in learners being able to identify their true understanding of the content. Having learners complete each question within time frame can more accurately gauge a learner's proficiency in these areas, as they cannot rely on extensive research or prolonged deliberation. It also reflects real-world constraints whereby decisions need to be made quickly, this also promotes the important skill of time management.

Memes often reflect current trends and experiences, making memes relatable to learners. Memes, using humour, assist in capturing learner's attention and make the feedback more enjoyable. However, it is also important to note that balance is important and that the overuse of the memes may distract from the actual feedback content.

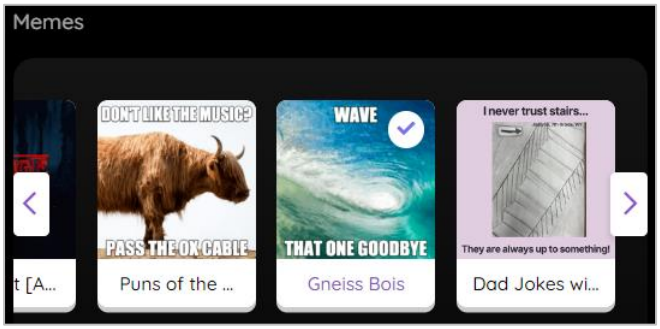


Figure D3: Memes in Quizizz

The concept of power-ups in a Quizizz design is to increase engagement and participation. These powerups are automatically assigned per question. For example, looking at the question below, one of three power-ups may be used, an Eraser, Immunity or Double Jeopardy. If the learner selected Immunity, 2 attempts are allowed for answering the same question.

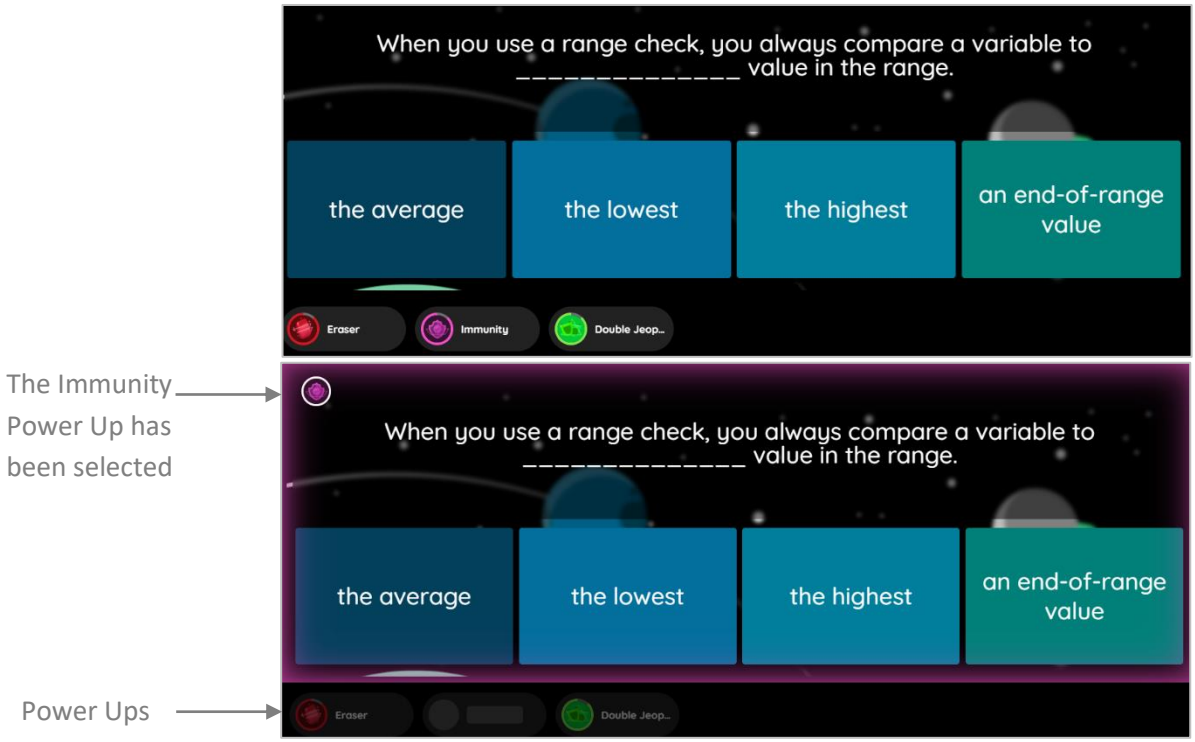


Figure D4: The use of Quizizz Power Ups

A list of some of the power-ups and their meaning implemented in the quiz.

Table A1: Some of the Power Ups Used in Quizziz

Graphic	Power-Up Type	What does it do?
	Supersonic	Players get 1.5x points for 20 seconds when they play at a faster speed.
	Streak Booster	Boosts the streak counter by +6 points to add to their current streak.
	Double Jeopardy	Players get double points if they choose the answer correctly but lose it all if they choose the wrong answer.
	2X	Players get twice the points for answering a question right.
	50-50	Eliminates half of the incorrect options.

The quiz consisted of various styles of questioning, for example:

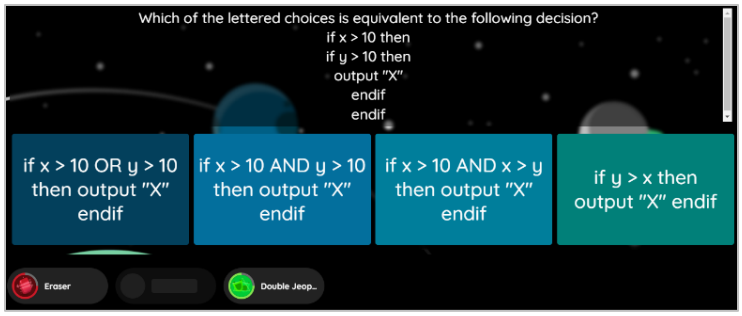


Figure D5: Example 1: Styles of Questioning in Quizizz

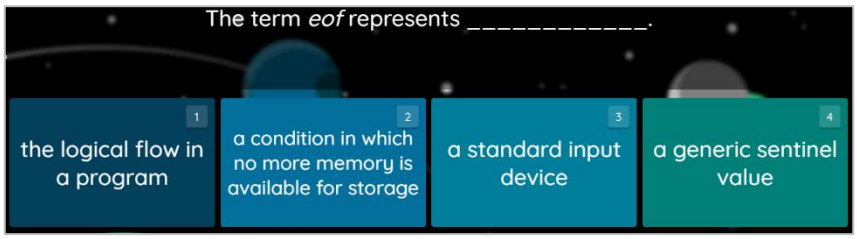


Figure D6: Example 2: Styles of Questioning in Quizizz

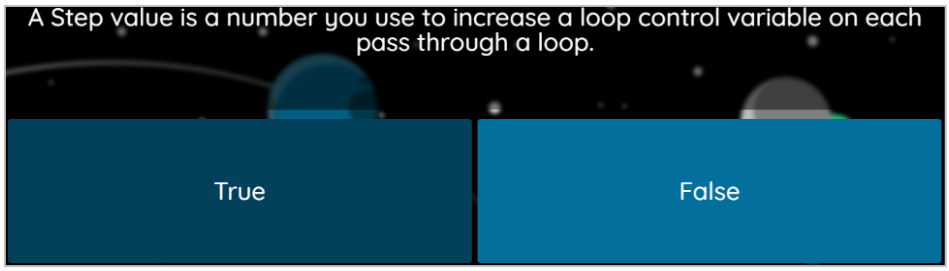


Figure D7: Example 3: Styles of Questioning in Quizizz

Real-time feedback was provided after each question. Along with an increase or decrease in total points scored and the learner's position on the scoreboard.

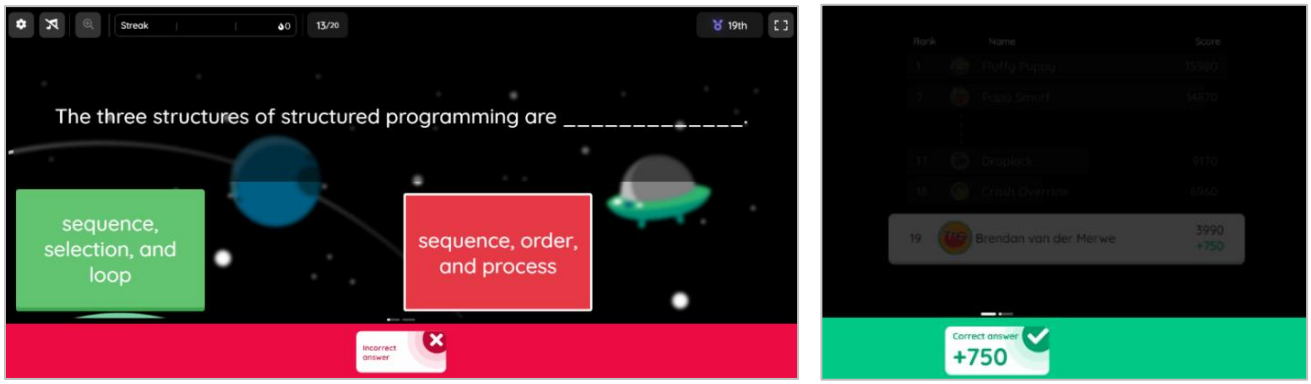


Figure D8: Feeback in Quizizz

During the quiz learners are given an opportunity to improve their accuracy using redemption questions. This design allows learners to re-attempt questions which were previously marked as incorrect.

Figure D9: Redemption Questions in Quizizz

Upon completing the quiz learners also receive, as feedback, a game summary which indicates their rank on the leaderboard, along with other statical related data as indicated in the Figure D10. The following process of receiving feedback – reviewing – replaying the quiz – taking a new quiz gives the learners the opportunity to reflect and improve.

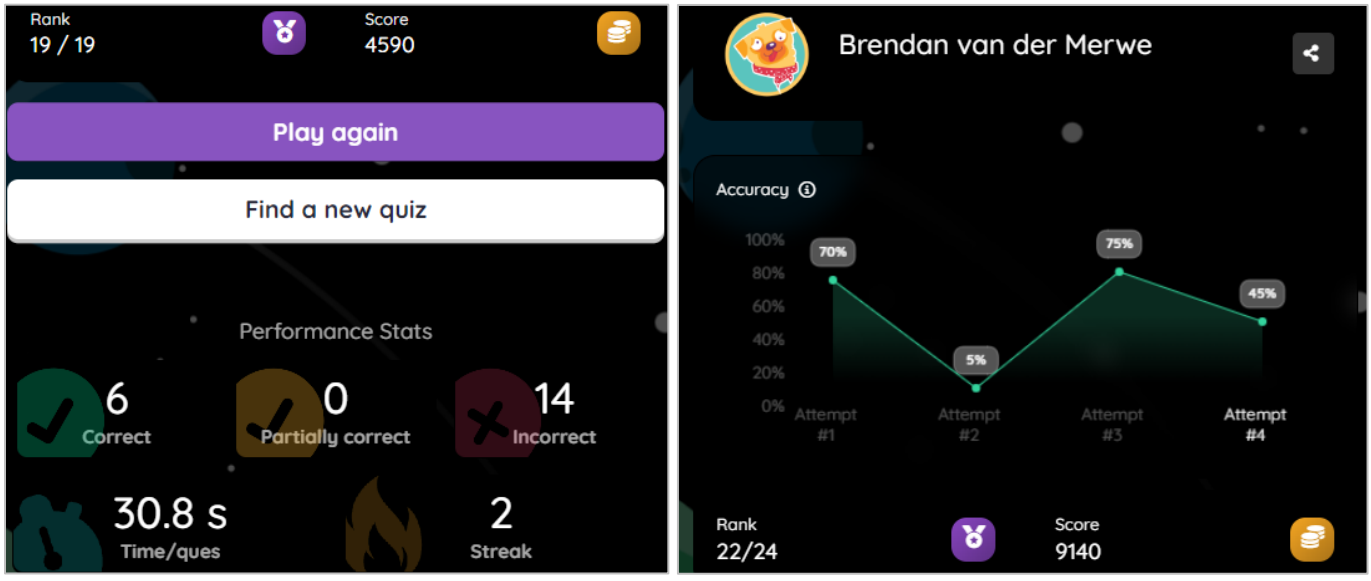


Figure D10: Game Summary in Quizizz

Activity 3 involved learners interacting and contributing to the discussion board on the LMS.

The focus of this learning activity was for learners to choose and implement selection structures in an algorithm based on a real-world scenario. The outcomes of the learning activity were to:

- Analyse and debate with classmate's the ethical challenges that will impact the design of the program
- Discuss and submit a possible solution to the given problem.

The following instructions were given to learners:

This learning activity looks at ethical considerations to consider when designing a program and the implementation of selection structures to solve a given problem.

In the medical field, it's common for healthcare facilities to face the challenge of insufficient organs available for transplant surgeries compared to the high demand from patients awaiting such procedures. Imagine you've been tasked with developing a computer program designed to choose one eligible candidate from a pool to receive an available organ.

Access the discussion tool on the LMS and engage in the following threads:

- Debate ethical challenges in designing a computer program for decision-making.
- Discuss the types of data to be utilised in your program's decision-making process (provide rationale).
- Explain your programming decisions (provide rationale).
- Specify the types of data you will not use in the decision-making process (provide rationale).
- Submit pseudocode demonstrating a basic selection structure for one decision in your program.
- Respond to at least one peer's post, explaining your agreement or disagreement.

With reference to Bloom's Taxonomy, this activity was particularly entrenched in analysis. However, the activity did require an understanding, through research, of the ethical considerations to consider when coming up with a design.

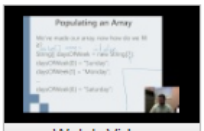
In Activity 4 learners needed to research Arrays and then complete a test, which was placed on the LMS. Learners needed to summarise Chapter 6, watch videos, and answer some questions prior to completing the test. The outcomes of the activity were to:

- Engage with the necessary resources to identify parts of an array.
- Complete the test on Arrays on the LMS.

The following instructions were given to learners:

STEP 1: Prepare for the test

Watch the following videos, consult Chapter 6 of your textbook, and complete the questions below in preparation for your test on Arrays.


Watch Video

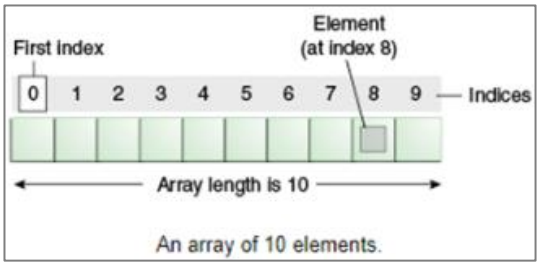
Different Ways to Populate an Array in Java
Duration: 3:23
User: n/a - **Added:** 29/01/15
YouTube URL: http://www.youtube.com/watch?v=JTXymK_jUdI

Watch Video

Array Explained In 1 Minute
Duration: 1:21
User: n/a - **Added:** 13/04/17
YouTube URL: http://www.youtube.com/watch?v=6tjYC86iV5E


Watch Video

Arrays Part 1 - Introduction into arrays
Duration: 16:27
User: n/a - **Added:** 13/04/20
YouTube URL: http://www.youtube.com/watch?v=flcDET8nMpI



- What is an array element?
- How would you specify the element you would like to access?
- What are the advantages of storing data in an array?
- Assume there are 10 learners in your class, how could an array be declared to store the 10 learner numbers?
- What are the naming conventions and/or guidelines for the naming of arrays?
- What is meant by populating an array?

STEP 2: Complete the test on Arrays on the LMS.

Examples of questions used in the test are indicated in Figure D11 and Figure D12.

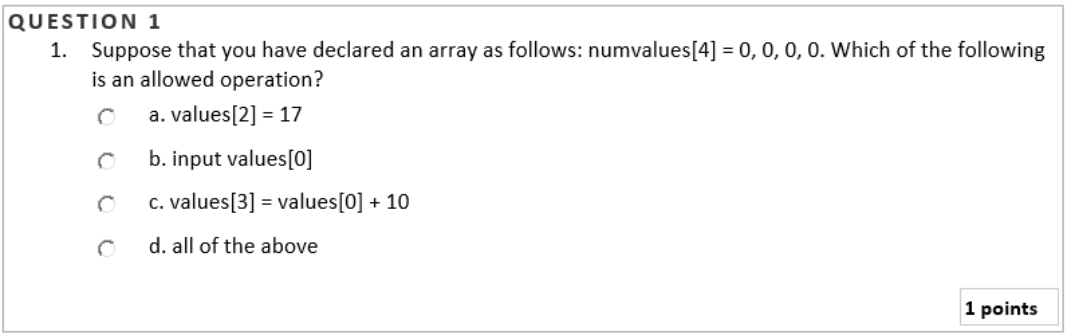


Figure D11: Type of Questions Used – Example 1

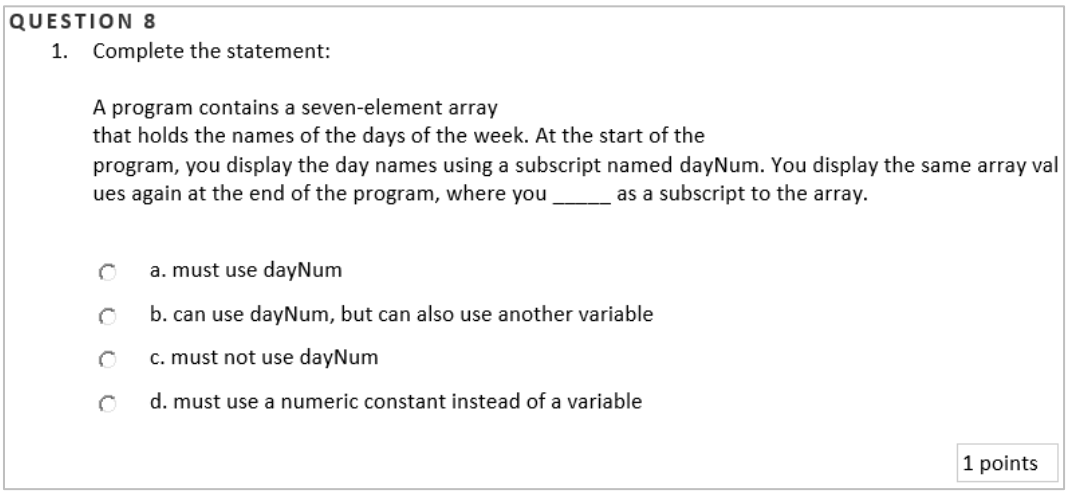


Figure D12: Type of Questions Used – Example 2

With reference to Bloom's Taxonomy, this activity was particularly entrenched in evaluation.

Appendix E: The Learning Activities in relation to Bloom's (revised) Cognitive Outcomes

Table E1: Bloom's Revised Taxonomy of Cognitive Outcomes for the Four Activities

Cognitive Outcomes	Activity 1	Activity 2	Activity 3	Activity 4
Remember				
Understand				
Apply				
Analyse			✓	
Evaluate		✓		✓
Create	✓			

Appendix F: Tools used in each Learning Activity

Table F1: Instruments/Tools Used by Learners in each Activity

Activity	Tools/Instruments
1	- Microsoft Visio (online version) - LMS (for submission)
2	- Quizizz - Textbook (Chapter 1 - 5)
3	- LMS (for engaging with the discussion board)
4	- LMS (for completing the test) - YouTube Videos - Textbook (Chapter 6)

Appendix G: Example of Coding and Categorising of Data in the Focus Group Interview

Text Colour Key:

Colour	Question type
	Main research questions
	Ad-hoc questions asked during the focus group
	Collective response from the focus group
	Extracts to form coding and potential themes

Coding: | **Themes (and other Ideas):**

Brendan: When you were working through the activities did you find that your engagement increased, decreased, or stayed the same? When you felt that you were engaging with activities, was it because of your personal motivation? And was the increase or decrease in engagement related to contextual issues outside of the classroom? (Part A: Activity/Task related – Question 1).

Benefits of Activity Engagement

Participant 1: These learning activities did increase my engagement, as it aided in enriching my skills. So, in my eyes, my thoughts on the activities is that it does help me to educate my personal skill to improve myself, even though mistakes were made, I was still learning and from the activities I was able to improve. Improve my modules (units of code) and everything. So, the activities did increase my motivation.

Potential Theme: student motivation levels rise when design thinking approaches are used in developing learning activities.

Depth of engagement

Participant 2: I found the activities helped go through each chapter. Because for me, if I was just reading through each chapter, reading though the work is not enough. With the activities I have to read and then understand the activity questions to actually engage my understanding of the content that I've been studying and reading. So, if I compare it to other subjects where we don't have these type of activities, there's actually a huge difference, there is a gap, compared to this subject where you have these activities. Going back, since high school, after each chapter or topic, it helps to go through activities and honestly, I'm not willing to go and look for activities to go through by myself. For any subject in this way. So, it was actually quite useful for me.

Reasons for not engaging.

Brendan: So, if you think back to high school, your engagement increased by having a structure at the end of each chapter, by having a set of exercises and activities, that you systematically went through, that will keep you focused and keep you on track?

[yes response, in agreement from the focus group]

Potential Theme: Consistent, frequent activities and assessment allows students to track their learning progress.

Reflection and Reflexivity (agency)

Participant 2: Yeah, because when I know there is going to be an exam or test those activities are useful as I can go through them to see how much I know, before I have the test. And you can see the mark you get before you study and the mark you get after you study there is a big difference, therefore it is quite useful.

Participant 3: In terms of high school versus university, it's more like high school it's more how well can you study the work? Whereas here, it is more, how well can you understand the work? And deal with those concepts to apply it to your knowledge. For me it is easy to study, I just have to make sure I understand the work.

Potential Theme: Transferring understanding and knowledge to apply concepts to real life problems (reference Blooms Taxonomy).

Brendan: It creates an experience to engage on a deeper level, deeper thinking, through that [process]?

Participant 3: Yes

Brendan: The next question is, considering the four activities, which features in the activities do you believe assisted you the most in engaging with the course content? (Part A: Activity/Task related – Question 2).To recap the activities, there was: designing and developing an IPO table, a flowchart and pseudocode in MS Visio [Activity 1], the gamified quiz [Activity 2], then the discussion board activity where you had to interact with other class members and contribute [Activity 3]. Lastly, the activity that dealt with researching and completing the test on arrays [Activity 4].

Benefits of Activity Engagement

Participant 1: Personally, I liked the first activity, the gaming activity (Activity 2], and the arrays quiz [Activity 4]. The reason I liked the first one is that it helped motivate me and build my curiosity. The activity contributed to making sure I correctly used [designed] pseudocode and flowcharts. Before we had just studied the pseudocode and flowchart, but never did it on our own. This was the first time doing it on our own.

Transition from theoretical to practical (Activity 1)

With the second activity, gaming is a fun thing, so it's a fun day. Getting feedback if you choose the correct answers, raises the learning experience.

Activity Feedback

Potential Theme: Consistent, frequent feedback increases engagement.

Brendan: So, getting response, initial feedback, as you've done something, helps you engage even more?

[yes response, in agreement from the focus group]

Appendix H: A section of the Focus Group Interview Summary (Coding, Themes, Direct Quotes)

Focus Group Questions	Coding	Theme	Data Extracts (direct quotes)	Points of Interest/ Notes
When you were working through the activities did you find that your engagement increased, decreased, or stayed the same? When you felt that you were engaging with activities, was it because of your personal motivation? And was the increase or decrease in engagement related to contextual issues outside of the classroom? (Section A: Activity/Task related – Question 1).	Benefits of Activity Engagement	Student motivation levels rise when design thinking approaches are used in developing learning activities.	"activities did increase my engagement" "aided in enriching my skills." "increase my motivation."	
	Depth of engagement		"With the activities I have to read and then understand the activity questions to actually engage my understanding of the content"	
	Reasons for not engaging.		"I'm not willing to go and look for activities to go through by myself."	
	Reflection and Reflexivity (agency)	-Consistent, frequent activities and assessment allows students to track their learning progress. -Transferring understanding and knowledge to apply concepts to real life problems.	"high school versus university, it's more like high school it's more how well can you study the work? Whereas here, it is more, how well can you understand the work? And deal with those concepts to apply it to your knowledge."	Reference Blooms Taxonomy
Considering the four activities, which features in the activities do you believe assisted you the most in engaging with the course content? (Section A: Activity/Task related – Question 2).	Benefits of Activity Engagement (Activity 1)	Advantages of student engagement	"build my curiosity"	
	Transition from theoretical to practical (Activity 1)	The necessity for theoretical underpinnings in coding.	Before we had just studied the pseudocode and flowchart, but never did it on our own. This was the first time doing it on our own.	
	Activity Feedback	Consistent, frequent feedback increases engagement.	Getting feedback if you choose the correct answers, raises the learning experience.	
	Gamification (Activity 2)	The competitive aspect within gamification increases engagement.	"entertaining" "motivated me to go through it a few times" "try and get the top score, it was competitive."	
	Exam style questions (Activity 4)	The benefit of having exam style questions within an activity.	"[Activity 4] was actually my favourite because it was like an exam setting"	
	Challenge appropriate activities.	The role of challenge appropriate activities related to engagement.	"[Activity 1] in the beginning it was kind of difficult and frustrating to figure it out, but it was helpful because I could work in my own time, that day, after college and try do it myself."	

Appendix I: Theme Maps

Overview of themes and subthemes from the predesign stage

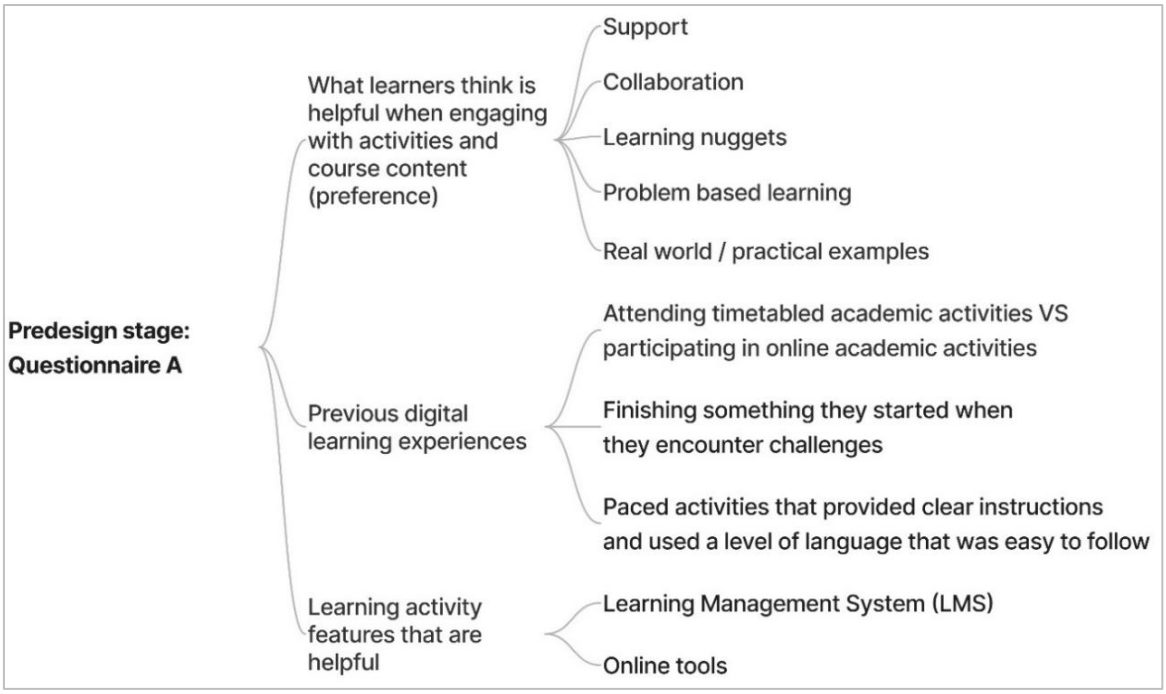


Figure I1: Themes and Subthemes from Questionnaire A (Predesign)

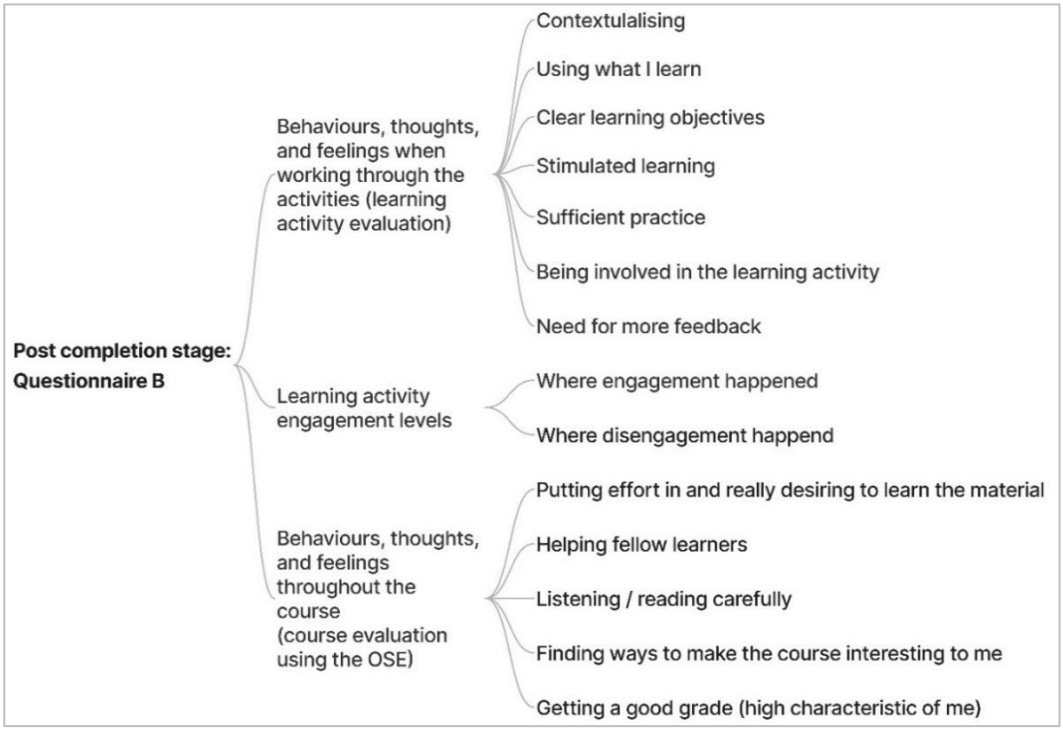


Figure I2: Themes and Subthemes from Questionnaire B (Post Completion)

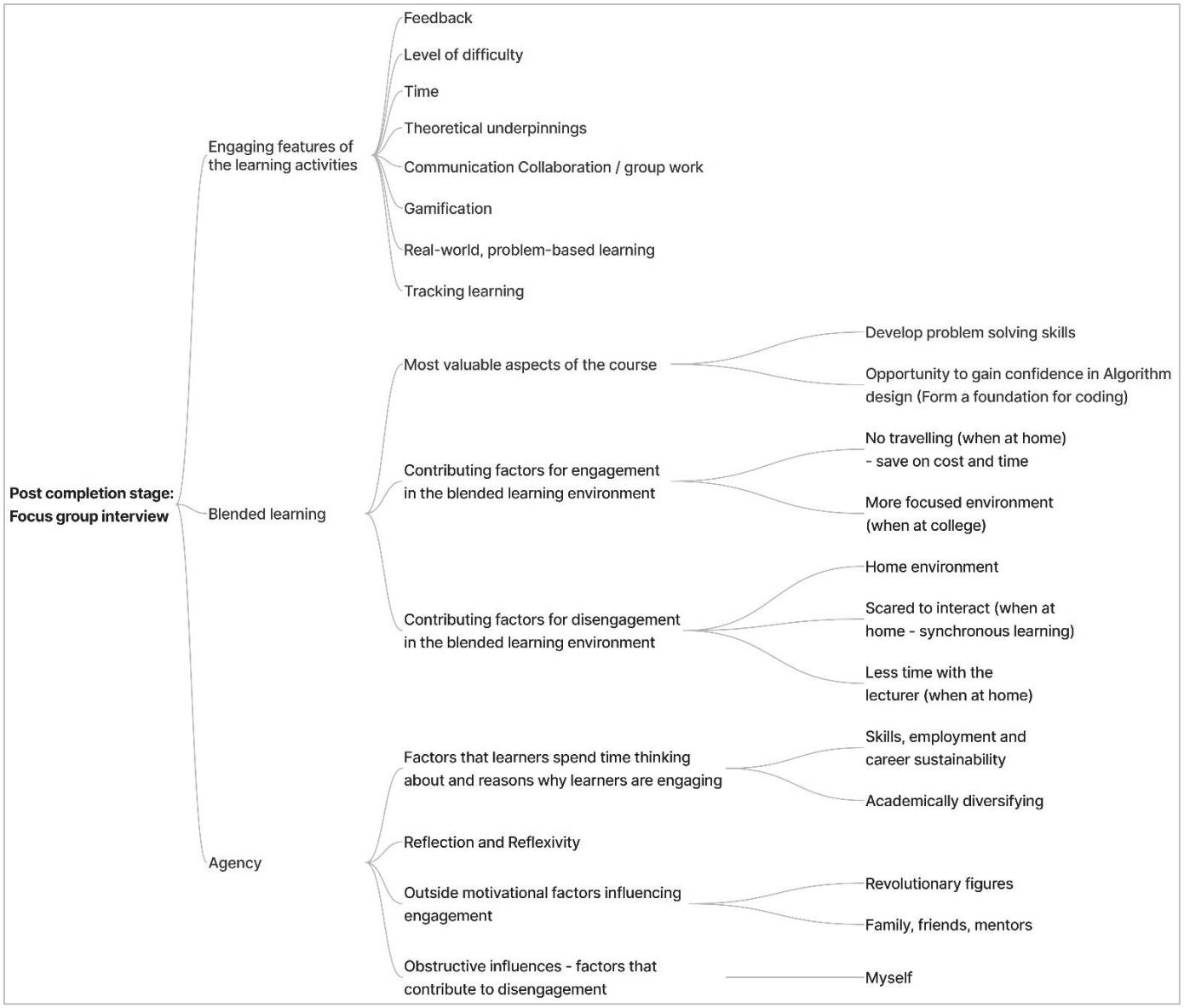


Figure I3: Themes and Subthemes from the Focus Group (Post Completion)

Appendix J: Consent Form

Dear Learner

Re: Request to Participate in three Research Questionnaires and, if selected, an Interview for my M.Ed research.

The title of my project is: "An investigation into the relationship between design approaches, learner engagement and agency in a blended learning Computer Science theory course".

This research (M.Ed) will involve two Questionnaires with approximately 60 learners and, if selected, one interview involving 7 participates. I would appreciate it very much if you would agree to participate in all of the questionnaires and possibly an interview. All participants will be asked the same questions. The questionnaires will take approximately 20 to 30 minutes to complete. The interview will last about one hour, and I would like to record the interview. This would be a semi-structured interview in which you (the interviewee) and I (the interviewer) will engage in a discussion around the research topic. For the Questionnaires and Interview there are no right or wrong answers as this is about your beliefs. The analysis of the data will not focus on individual learners but on learners' patterns, as I am aiming to develop interventions that will help as many learners as possible.

Your participation in this process is entirely voluntary and if you decide not to participate, I will fully respect your decision. If during the questionnaires or interview you decide to terminate your involvement in the process, once again your decision will be fully respected. I would like to record and transcribe the interview. A copy of the transcript will be given to you for verification. Your interview and the data taken from the questionnaires and interview will be kept completely confidential. Your name will not be mentioned in the dissertation or in any subsequent scholarly publications or presentations, a codename will be used instead.

There is no direct benefit for participating in this research. The results of this research can, however, be used to improve learning design, development and evaluation and the quality of teaching and learning. If you are willing to participate in this study, please sign this letter as a declaration of your consent, i.e., that you participate in this project willingly and that you understand that you may withdraw from the research project at any time. Respondents will by no means be subjected to prejudice because of their answers and participation will not affect their academic results.

Participation in this phase of the project does not obligate you to participate in the follow up interview, however, should you decide to participate in the follow-up interview your participation is still voluntary, and you may withdraw at any time. Under no circumstances will the identity of interview participants be made known to any parties/organisations that may be involved in the research process and/or which has some form of power over the participants.

Agree to take part:

- I agree to participate in this research project understanding that my participation is voluntary, and that confidentiality will be maintained.
- I have read this consent form and the information it contains and had the opportunity to ask questions about them.
- I agree to my responses being used for education and research on condition my privacy is respected, subject to the following:
  - I understand that my personal details will be used in aggregate form only, so that I will not be personally identifiable.
  - I understand that I am under no obligation to take part in this project.
  - I understand I have the right to withdraw from this project at any stage.
  - I understand that this research might be published in a research journal or book. In the case of dissertation research, the document will be available to readers in a university library in printed form, and possibly in electronic form as well.

I consent to:	**YES**	**NO**
1. A Questionnaire (before the four activities)		
2. A Questionnaire (after the four activities)		
3. Being observed whilst working through the four activities		
4. Being interviewed (if selected)		
5. Audio- recording of the interview (if selected)		

I _____*name* _____ agree to participate in the research process on the above terms.

Signature of Participant:

Signed by candidate

_____ Date: _____

Name of person who sought consent: Brendan van der Merwe

Signature of person who sought consent: _____

Signature of principal researcher:

Signed by candidate

_____ Date: 20/01/2022

Brendan van der Merwe

For further information regarding this study, or if participants feel any discomfort in answering some of the questions, please contact the principal researcher, Brendan van der Merwe, at: 0785588863 or VMRBRE002@myuct.ac.za

Yours sincerely,

Brendan van der Merwe

Appendix K: UCT Ethical Clearance

SCHOOL OF EDUCATION

Dr Carolyn McKinney
Associate Professor

University of Cape Town, Private Bag X3, Rondebosch, 7701
Physical address: Neville Alexander Building, University Ave South, Upper Campus
Tel: +27 (0) 21 650 2757 / 2772 Fax: +27 (0) 21 650 3489
E-mail: carolyn.mckinney@uct.ac.za http://www.education.uct.ac.za/edu/staff/academic/cmckinney

EDNREC20220202

22 February 2022

Brendan van der Merwe

M.Ed

Dear Mr van der Merwe

Re: Ethical Clearance for Research Project

I am pleased to inform you that ethical clearance has been granted by the School of Education Research Ethics Committee of the Faculty of Humanities for your research project entitled: 'An investigation into the relationship between design thinking approaches, student engagement and agency in a tertiary blended learning Computer Science theory course'.
I wish you all the best with your study.

Yours sincerely,

Signed by candidate

Associate Professor Carolyn McKinney
Chair - School of Education Research Ethics Committee

Appendix L: Request Letter to Conduct Research (Information Sheet)

Dear Learner

Research into Learner Engagement in a Tertiary Computer Science Theory Course

I, Brendan van der Merwe, a student researcher completing a Masters degree in the School of Education at the University of Cape Town would like to ask your permission to carry out research on the relationship between design approaches, learner engagement and agency in your Programming Logic and Design module.

This research will explore why learners may disengage when learning Computer Science theory, with reference to designing, developing, and evaluating eLearning interventions in the form of blended learning activities. The aim is to design rich learning experiences that embody meaningful architecture and rich patterns to increase learning and performance. Respondents will be observed, questioned, and possibly interviewed throughout the four activities over a two-month period.

Data collection will be in the form of a questionnaire before the learning activities, a brief questionnaire after each learning activity and a questionnaire towards the end of the four activities and course. General observations will be noted whilst learners work through the activities. You may be asked to be interviewed at the end of the four activities. This will offer an opportunity to pursue any areas of interest that may have arisen during data collection.

Participation is voluntary and the confidentiality of the you, the learner, and the college is guaranteed. The college will be given a pseudonym (different name), and pseudonyms will be used for all participants in the writing up of the research. Respondents will by no means be subjected to prejudice because of their answers and participation will not affect their academic results. You may withdraw permission for conducting the research at any time.

Please may you fill in the consent form to indicate your consent for the research.
You are welcome to ask any questions regarding this research by telephone or email to me: on 0785588863 or VMRBRE002@myuct.ac.za

Yours sincerely,
Brendan van der Merwe

Appendix M: Data Management Plan

Table M1: Data Management Plan

Element	Description
Data collection and description	Original data was collected using the methods discussed in Chapter 3. Data was in the form of text (field notes, survey responses), numeric (counts, measurements and LMS tracking statistics), audio (sound recording).
Data curation and storage	Under the Protection of Personal Information Act (POPIA) legislation, personal information collected was solely for the reason it was originally collected for, and that the data will be securely deleted/destroyed when the records have served their purpose. The gathering and processing of data utilised the following software applications: Google Forms, Microsoft Word, and Excel. The de-identification of data sets occurred at the earliest opportunity therefore minimising the risk of re-identification. Data was stored on cloud storage, Microsoft OneDrive.
Data Security	Emphasis was placed on POPIA legislation, which required that personal information collected and processed be kept secure. To ensure that personal information is safeguarded, the following restrictions governing data was in place: - Adopt a Clean Desk policy whereby all confidential information is securely locked away when not in use. The computer screen was locked when I was not at my desk and sensitive documents were not left at my desk for just anyone to see. Access to the researcher's computer and the Microsoft Excel document was password protected. Microsoft OneDrive is a secure cloud storage, that assisted in the prevention of data loss and increased data security. Access to Microsoft OneDrive was password protected and formed a secure data repository. - Backup and storage of data/information was on the correct devices only. Only Microsoft OneDrive was used for backing up and storage of data. Workings were double checked to verify that work is saved to the correct folders and directories so the backups can sync successfully. - Making sure to run all the necessary software updates on the computer being used to ensure Virus Protection. In addition, the antivirus software was always up to date by running updates when notified. This aided in keeping the system free of malicious software and viruses
Data sharing and reuse.	Abiding by the POPIA legislation, the destruction or deletion of a record of personal information will be done in a manner that prevents its reconstruction in an intelligible form. Data will be retained for the period of this research study only.