

Selection criteria for serious games to assist students in learning programming concepts

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DECLARATION

I, **Lewis Msosa** declare that **Selection criteria for serious games to assist students in learning programming concepts** is my own work and that all the sources I have used or quoted have been indicated and acknowledged by means of complete references.



Signature: _____

Date: 18th November 2019



To Whom It May Concern:

PROOF OF LANGUAGE EDITING – LEWIS MSOSA DISSERTATION

This serves to confirm that I, Sibongile Ndhlovu – Freelance Editor – solemnly swear that I have proofread and edited the dissertation of Lewis Msosa that he submitted in fulfillment of the requirements for his Masters Degree of Science in Computer Science at the North West University, South Africa. The dissertation is titled *Selection criteria for serious games to assist students in learning programming concepts*.

If you have any queries, please do not hesitate to contact me.

Yours Faithfully,



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DEDICATION

This is dedicated to my family and friends, but most importantly to my mother and brother who supported me through all my endeavours.

ACKNOWLEDGEMENTS

This research not only has it inspired me to strive to acquire more knowledge, but it has also showed me the path of infinite possibilities in learning and self-discipline. However, I could not have accomplished this journey alone, so I would like to thank the following:

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- My family, both my parents and siblings for believing in me and making it possible for me to have this opportunity and the everlasting experience.
- Above all, I would also like to thank God for everything, both the good and bad that has helped to shape me into the person that I am today.

ABSTRACT

There is a general consensus among tertiary institutions that the number of students enrolled in the computer science field seems to be on the decline. Programming is considered as the cause of this trend as most students consider programming difficult to master. To enhance students' learning, researchers have explored the possibility of using technology, such as Personal Computers (PCs) and smartphones. Researchers have noted that most students seem tech savvy and enjoy playing video games in their spare time; hence, serious games have also been considered. Therefore, the aim of this study was to identify and use selection criteria for serious games that could assist students in learning programming concepts.

A set of primary and secondary objectives was set. The primary objective was to identify and use selection criteria for serious games to assist students in learning programming concepts. To achieve this objective however, a set of secondary objectives were derived by means of theoretical and empirical objectives. These theoretical objectives were to search the literature for available criteria to select serious games for learning concepts, to identify attributes that define a good serious game, to identify serious games for learning programming concepts and to identify important factors in learning fundamental programming concepts. The empirical objectives of the study were to evaluate the suitability of the identified serious games in learning fundamental programming concepts against the game attributes identified during the literature study and to identify and use selection criteria to identify good serious games that could assist students in learning computer programming concepts.

To accomplish this, an Action Research (AR) approach was adopted by collaborating with educators to determine how to use game attributes to select a serious game. The selection criteria model was then evaluated and analysed by interviewing educators for necessary feedback. Then, to validate the model as proof of concept, the participants used the presented selection criteria model to evaluate a series of serious games as they relate to the learning of programming concepts.

Keywords: Serious Games, Action Research, Programming Concepts, Selection Criteria.

TABLE OF CONTENTS

DECLARATION.....	i
DEDICATION.....	iii
ACKNOWLEDGEMENTS.....	iv
ABSTRACT	v
TABLE OF CONTENTS	vii
LIST OF TABLES.....	x
LIST OF FIGURES	xi
LIST OF ABBREVIATIONS.....	xii
CHAPTER ONE: INTRODUCTION.....	1
1.1 Introduction	1
1.2 Background.....	1
1.3 Computer Science in tertiary education.....	2
1.3.1 Education environment	2
1.3.2 Technology in the learning environment.....	3
1.3.3 Serious games.....	3
1.4 Problem statement.....	5
1.5 Objective of the study	5
1.5.1 Primary Objective	5
1.5.2 Secondary Objectives	5
1.6 Research design and methodology.....	6
1.6.1 Literature review	6
1.6.2 Empirical study	6
1.7 Ethical considerations	9
1.8 Contribution of the study	9
1.9 Delineations and limitations	9
1.9.1 Technical limitations.....	10
1.9.2 Language limitations	10
1.10 Research layout.....	10
CHAPTER TWO: LITERATURE REVIEW.....	12
2.1 Introduction	12
2.2 Information Communication Technologies (ICTs) in education	12
2.3 A Game-based approach in education and Serious Games.....	14
2.3.1 Serious Games	15
2.3.2 Serious Games in Education.....	19
2.3.3 Appropriate Serious Games Evaluation Methods	23

2.3.4	Serious Games in Programming	25
2.4	Learning Programming and Mobile Devices.....	31
2.4.1	Novice Learners and Programming.....	31
2.4.2	Basic Programming concepts	32
2.4.3	Learning Programming through Mobile Devices.....	34
2.5	Conclusion	36
CHAPTER THREE: RESEARCH DESIGN AND METHODOLOGY		37
3.1	Introduction	37
3.2	Research Philosophy	38
3.3	Research Paradigms	38
3.3.1	Positivism	40
3.3.2	Interpretivism	41
3.3.3	Constructionists or Critical Social Theory.....	43
3.3.4	Design Science Research.....	44
3.4	Positioning the Study	44
3.5	Action Research	45
3.5.1	Concepts central to AR	45
3.5.2	AR process	47
3.5.3	Critical Social theory perspective of AR approach.....	48
3.6	Data Collection Techniques	50
3.6.1	Interviews	52
3.6.2	Interview guidelines	52
3.6.3	Qualitative Data Analysis	54
3.7	Research Process of this study.....	55
3.8	Conclusion	57
CHAPTER FOUR: EMPEIRICAL FINDINGS.....		58
4.1	Introduction	58
4.2	Research Approach	58
4.3	Application of the AR Process Model	59
4.4	Pilot study	60
4.5	Action Research: Cycle one	62
4.5.1	Diagnosis.....	62
4.5.2	Action Planning.....	69
4.5.3	Action Taking	72
4.5.4	Evaluating	72
4.5.5	Specified Learning	75
4.6	Action Research: cycle two	75

4.6.1	Diagnosis.....	76
4.6.2	Action Planning.....	76
4.6.3	Action taking	80
4.6.4	Evaluating.....	81
4.6.5	Specified Learning	85
4.7	Conclusion.....	85
CHAPTER FIVE: CONCLUSIONS, REFLECTIONS AND RECOMMENDATIONS		86
5.1	Introduction.....	86
5.2	Research Conclusions	87
5.2.1	Cycle one.....	87
5.2.2	Cycle two	87
5.3	Research Findings.....	88
5.3.1	Cycle one findings	88
5.3.2	Cycle two Findings.....	89
5.4	Challenges and Recommendations	90
5.4.1	Research Challenges.....	90
5.4.2	Future study recommendations.....	91
5.5	Conclusion.....	91
REFERENCES		92
APPENDIX A: Serious Games List in Computer Programming		104
APPENDIX B: Interview Guideline		105
APPENDIX C: Participants' Sample Response Transcripts and Notes		109

LIST OF TABLES

Table 2-1: Bloom's taxonomy and game attributes	21
Table 2-2: Game attributes in line with serious games.....	22
Table 2-3: Serious games evaluation methods	23
Table 3-1: Research paradigms and their philosophical assumptions	40
Table 3-2: Characteristics and forms of action research	47
Table 3-3: Critical Social Theory Elements	49
Table 3-4: Critical Social Theory (CST) principles.....	49
Table 3-5: Data collection techniques	50
Table 3-6: Interview types	52
Table 3-7: Guidelines for conducting interviews.....	53
Table 3-8: Stages during an interview.....	53
Table 4-1: Sample interview questions.....	64
Table 4-2: Code and quote from participant's response.....	66
Table 4-3: Identified main themes from transcripts	67
Table 4-4: Serious game evaluation model.....	70
Table 4-5: SUS questions and evaluation analysis	73
Table 4-6: SUS responses of Participants.....	74
Table 4-7: Evaluation Analysis and SUS Questions.....	81
Table 4-8: SUS responses of participants.....	83
Table 4-9: Serious games and game attributes.....	84
Table 5-1: Participants' perception of game attributes	88
Table 5-2: Participants' game scoring	89

LIST OF FIGURES

Figure 1-1: Action Research Cycles.....	7
Figure 2-1: Image of Serious games in programming	26
Figure 3-1: Action Research cycle	48
Figure 4-1: AR process model.....	59
Figure 4-2: Cycle one AR summary	62
Figure 4-3: Cycle two AR summary.....	76
Figure 4-4: Light – bot	78
Figure 4-5: RoboZZle Droid.....	79
Figure 4-6: Algorithm City.....	80

LIST OF ABBREVIATIONS

A R	Action Research
CSS	Cascading Style Sheet
CST	Critical Social Theory
HEI	Higher Education Institution
HTML	Hypertext Markup Language
ICT	Information Technology and Communication
IT	Information Technology
SG	Serious Games
PS	Pilot Study
PCs	Personal Computers
SUS	System Usability Scale

CHAPTER ONE: INTRODUCTION

1.1 Introduction

There is a noticeably declining trend in tertiary institutions with regard to student enrolment in computer science. This is an alarming situation when considering the role of information communication and technology (ICT) today. Programming is regarded as a deterrent factor for this trend as most students consider it difficult to master (Jordine *et al.*, 2015; Malliarakis *et al.*, 2014). However, mobile devices have increasingly become prevalent amongst the population as a form of entertainment through mobile games, more so with the younger generation (Su & Cheng, 2015). This in turn has created an opportunity to incorporate digital games into the learning environment (Heintz & Law 2012). Mobile technology has also shown to allow students to learn anywhere and anytime (Bartel & Hagel, 2014). Therefore, the serious games phenomena have been considered to play a significant part in enhancing the teaching and learning process for both tutors and learners (Wang & Tseng, 2014). Learning and teaching may become easier with the intervention of such technologies (Ibrahim *et al.*, 2011).

This chapter addresses the overall layout and motivation behind this study in the form of a background, the methodology adopted, and the participant's selection. It also highlights the problem statement and the objectives of the study. Finally, the ethical clearance that was adopted in this study is also highlighted.

1.2 Background

This section addresses some of the key concept areas with regard to the research. The areas discussed are computer science in tertiary education, serious games, technology in the learning environment and the education environment.

1.3 Computer Science in tertiary education

Tertiary institutions experience minimum growth in the number of enrolments in computer science. Several studies report a declining trend in the number of enrolments for computer science (Gomes & Mendes, 2010; Heersink & Moskal, 2010; Muratet *et al.*, 2011). However, Jackson and Moore (2012) argue that the US labour market has shown an increase of 45.3 percent in software development careers making it one of the fastest growing sections in software design occupations in 2008. Kirlidog *et al.* (2011, unpublished) point out that the enrolment for computer science in South Africa was a steady but disappointing increase of 3.4 percent compared to the healthy increase of 27.4 percent in all other subjects from 2005 to 2010. This is a major concern when considering the role of technology today. Unrelated course material and learning content could be to blame for these low enrolment figures in computer science (Kurkovsky, 2013).

Programming is part of almost all computer science curricula and there is a perception that programming is a difficult skill to master. This perception stands out as a major problem when the reasons for the low enrolment figures in computer science are addressed (Khaleel *et al.*, 2015, Peters & Pears, 2012). Kotovsky (2003) insinuates that the programming environment requires higher order thinking skills, which include problem solving abilities. Furthermore, today's digital environment requires from students the ability and fundamental skills to solve problems (Nag *et al.*, 2013). Stanescu *et al.* (2011) argue that students easily solve problems when they are motivated and use a rather hands on approach. When problem solving and programming problems are presented in a context that students can relate to, they are more motivated and have a better understanding of what proper solutions should entail (Tan & Rahaman, 2009). Algorithms play an essential role when solutions to problems are developed in a programming environment. Shabanah and Chen (2009) argue that algorithms should be presented in ways that make sense to students.

1.3.1 Education environment

Conneely *et al.* (2012) argue that tech-savvy students of the twenty-first century have different learning requirements although education systems have remained the same

over the years. The conventional learning environment has proven to be less effective for digitally-connected students, especially in a resource-constrained learning environment (Cunningham, 2015). A new education environment is needed where students are involved in the classroom and learning is relevant to the requirements of the changing world (Kaiser & Wisniewski, 2012). The digital environment expects and encourages students to be active participants rather than passive observers (Prensky, 2001). A change in current and traditional teaching strategies is required if the needs of the new generation of digitally-oriented students are to be met (Zeeman, 2014).

1.3.2 Technology in the learning environment

Information technology has the potential to benefit students when applied properly (Mbogo *et al.*, 2014). Technology has demonstrated motivational effects when used in the learning environment (Schwabe and Göth, 2005). Furthermore, technology fast-tracks and enriches basic skills and prepares students for the industry at a young age. This is done by easing tasks through new methods such as games and simulations, to digitally-enabled students (Lemke, 1999). Specifically, games can transform the traditional learning spaces into powerful and effective learning environments (Wrzesien & Alcañiz Raya, 2010). An environment where innovative student-centred learning is supported by serious games is vital, since traditional education-spaces no longer appeal to today's students (Rooney, 2012). However, the recent decade has witnessed increased popularity of mobile games for entertainment (Su and Cheng, 2015). In turn, this has created a generation that is fluent in games and social media (Bidarra *et al.*, 2015). Video games are increasingly becoming popular and researchers have considered serious games as a phenomenon that can entice learners due to its unique motivation and user involvement capabilities (Zyda, 2005; Djaouti *et al.*, 2011; Su and Cheng, 2015). Some progress has been made to incorporate digital games into the learning environment, even more so using mobile technology (Heintz & Law 2012; Bartel & Hagel, 2014).

1.3.3 Serious games

A serious game is a game that is created with a primary objective other than just entertainment (Djaouti *et al.*, 2011). Serious games are used by various industries

such as the military, healthcare, engineering, politics and education (Serrano-Laguna *et al.*, 2017; Marquez-Tellez *et al.*, 2017; Mavridis *et al.*, 2012).

The idea of adopting a playful approach in education for motivational purposes is a well-established research concept (de Villiers & Blignaut, 2016). The research community has been investigating ways in which games can be used to enhance the learning process (Bellotti *et al.*, 2009). Serious games are important in complementing teaching and learning processes for various education sectors (De Jans *et al.*, 2017). Current educational methods are bound to change, as both learners and technology advancements dictate how information is consumed, and educational institutions also seek better ways of teaching and disseminating information (Callaghan *et al.*, 2015; Krassman *et al.*, 2015; Wang & Tseng, 2014).

Serious games introduce a unique user experience that provides seamless integration between learning and entertainment (De Villiers & Blignaut, 2016). The purpose of serious games is to solve real problems (Ribeiro *et al.*, 2013). It is crucial that pedagogy does not supersede the core nature that makes up the game when it comes to serious games in education (de Villiers & Blignaut, 2016). But sometimes a serious game can be non-entertaining depending on the nature of the problem being addressed (Backlund *et al.*, 2008).

Serious game developers should always find a balance between fun and being instructional whenever creating such games (Fitchat & Jordaan, 2016). Serious games are not only motivational but include other attributes such as reward, interactivity, score and challenge (Vogel *et al.*, 2006). The purpose of serious games can go beyond educating and entertaining as it can embed a deeper understanding of the learning material (Charsky, 2010). Serious games entail that learners learn by performing the required task, allowing them to grasp concepts better when compared to a conventional learning setup (de Villiers & Blignaut, 2016).

1.4 Problem statement

Students find it difficult to learn computer programming, resulting in their loss of interest, and in some cases, they eventually develop a negative mindset for the subject (Khaleel *et al.*, 2015). However, some studies indicate that serious games can provide the required solution for this problem, by minimising the level of boredom for the learners (Pranantha *et al.*, 2012; Khaleel *et al.*, 2015; Mbogo *et al.*, 2014). There are several frameworks that aim to help tutors and learners to select serious games (Prinsloo & Jordaan, 2014). But the current frameworks for incorporating serious games in the learning environment lack a comprehensive application of serious game attributes (Göbel, 2016). This research aimed to address this gap by proposing selection criteria made of gaming attributes for choosing an appropriate serious game to assist students in learning computer programming concepts.

From this short introduction the following research questions arose:

- Which attributes are essential in characterising serious games for selection to learn computer programming concepts?
- How can serious games attributes be applied as selection criteria to comprehensively evaluate a serious game for computer learning programming concepts?

1.5 Objective of the study

1.5.1 Primary Objective

The primary objective of this research was to identify and use selection criteria for a serious game to assist students in learning programming concepts.

1.5.2 Secondary Objectives

To achieve the primary objective, the following theoretical and empirical objectives were formulated for the study:

1.5.2.1 Theoretical objectives

The following theoretical objectives were derived:

- Search the literature for available criteria for selection frameworks to select serious games for learning programming concepts.
- Identify game attributes that define good serious games.
- Identify serious games for learning programming concepts.
- Identify concepts which are important in learning fundamental programming concepts.

1.5.2.2 Empirical objectives

The following empirical objectives were derived:

- Evaluate the suitability of identified serious games to assist students in learning fundamental programming concepts against the game attributes identified during the literature study.
- Use selection criteria to identify serious games to assist students in learning computer programming concepts.

1.6 Research design and methodology

The study comprised a literature review and an empirical study, which entailed a qualitative research methodology.

1.6.1 Literature review

A review of the literature was conducted using relevant online academic databases (Google Scholar, EBSCOhost, ScienceDirect, Scopus, etc.), journal articles and textbooks.

1.6.2 Empirical study

As shown in figure 1, the empirical portion of this study followed the sequence of the action research process model, through a Critical Social Theory perspective (CST). Action Research (AR) is considered a qualitative and interpretive method that originates from traditional social science methodologies (Brydon-Miller, 2001; McTaggart, 1991). AR allows researchers to work with participants to identify a social

problem by following a process of fact discovering, conceptualisation, planning, implementation and evaluation; in turn this process simultaneously allows them to resolve the problem and generate novel knowledge (Khan & Chovanec, 2010). On the other hand, Baskerville (2008) state that AR is a research method that focuses on solving problems “through social and organisational change.” Action researchers take part in discussions to plan, execute improvement actions, join a problem situation, and they critically reflect on expressed learnings (Checkland & Holwell, 1998).

Adopted from (Riel, 2010)

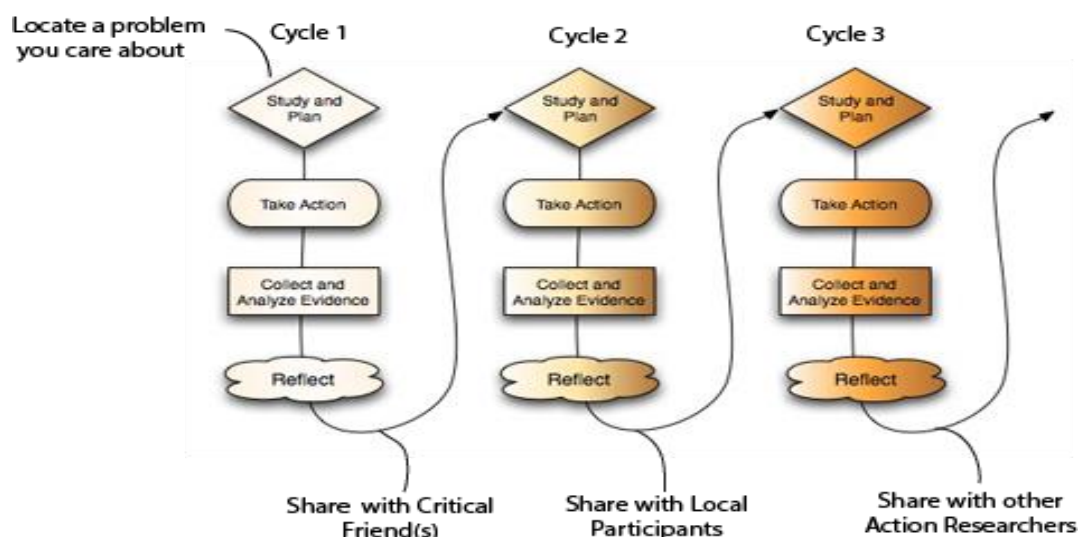


Figure 1-1: Action Research Cycles

Susman and Evered (1978) describe the AR method as an iteration of five phases namely diagnosis, action planning, action taking, evaluation and specification of learning. Diagnosis phase 1) - identifies the primary reasons for the needed change, the development of theoretical assumptions about the problem context and holistic interpretation of the problem situation. Action planning phase 2) - determines the actions to relieve the problem, in line with a change approach. Planned actions phase 3) - helps implement the action taking phase. Evaluation phase 4) - outcomes of the implemented actions and the extent to which the problem was resolved are assessed in this phase. 5) Specification of learning phase 5) - this phase deals with the identification and recognition of new knowledge gained (Baskerville, 1999).

During the empirical part of the study, qualitative research within the interpretive paradigm was conducted (Klein & Myers, 1999). Semi-structured interviews were used to gather data. The collected data was analysed and discussed. The empirical portion of this study comprised the following methodology dimensions:

1.6.2.1 Participants and participant selection

The participants for this research study were selected through purposive sampling (Patton, 2002). This sampling approach was selected so that the perceptions of participants with specific characteristics could be investigated. For inclusion in this study, participants needed to lecture computer science and be comfortable with using mobile devices. These two criteria were selected so that relevant insights about programming concepts using serious games on mobile platforms might be explored. To this end, lecturers from a South African Higher education Institution (HEI) were approached to participate in this study. Participants were selected so that gender and age were adequately represented.

1.6.2.2 Data collection methods

Interviews, questionnaires and observations are frequently used to collect data in the field of serious games (Rogers *et al.*, 2011). Interviews are generally classified as being unstructured, structured or semi-structured. For this study, semi-structured interviews were conducted with each participant individually. Interviews were conducted until data saturation was reached. Data was gathered by audio recording these interviews and transcribing the relevant sections.

1.6.2.3 Data analysis methods

Verbatim transcriptions of the relevant sections of the conducted interviews were analysed and the recurring themes were identified through data coding. Data coding entails labelling sections of the transcriptions to organise these sections from which themes may emerge and conclusions can be drawn (Miles & Huberman, 1994).

1.6.2.4 Rigour and evaluation of methods

Shenton (2004) provides strategies for achieving trustworthiness of qualitative research. The trustworthiness of the data in this study was ensured through participation validation and by providing participants with the interpretation of the collected data.

1.7 Ethical considerations

This research study was executed in such a manner that it complies with the ethical standards of academic research. Participants were not requested to disclose any information that might identify them or others. All information was handled confidentially and was only used for research purposes and then in an accumulated form. Participation was completely voluntary, and any participant could withdraw at any time. Sample questions for the interviews were submitted to the Ethics Committee of the HEI for approval and ethical clearance **NWU-001173-19-S9**.

1.8 Contribution of the study

This study seeks to identify selection criteria for serious games to introduce and help students to learn difficult programming concepts. This will lead to a better understanding of programming, which, in turn, may assist in better throughput rates in computer programming modules offered at tertiary institutions.

Additionally, the findings of this study have contributed to the literature regarding ICT in the South African context.

1.9 Delineations and limitations

This study seeks to identify selection criteria for serious games that can assist students in learning programming concepts and in that regard, the study only focused on existing games that addressed specific programming concepts such as algorithms and abstract interpretation of logic structures. In addition, it was imperative to identify

serious games that are free and open source for use. The study also focused on serious games that were generic to a mobile platform, in this case it is the android platform as such technology is prevalent with students in a low resource setting and at the HEI. In that regard, the nature of the identified serious games brought in its technical limitation:

1.9.1 Technical limitations

- Device: Smartphone or tablets only
- Operating system: Android 4.2 or higher

1.9.2 Language limitations

- The preferred language for the identified serious games has instructions and the interface is strictly in English.

1.10 Research layout

This study comprises the following chapters:

Chapter one: Introduction

The first chapter covered the introduction and the background of the study. It included the outline of the problem statement culminating in the primary objective from where the research questions are derived. It concluded with a brief outline of the complete study.

Chapter two: Literature Review

The second chapter outlines and explains the key concepts of the research. In this case, it elaborates on the serious games concept, its attributes and serious games in computer programming.

Chapter three: Research Design and Methodology

Chapter three includes a discussion of the qualitative empirical research. Furthermore, the sampling frame, the sampling method and the sample size will be highlighted. The techniques used for the data analyses were also discussed.

Chapter Four: Empirical findings

This chapter presented the study's findings. The findings were analysed, interpreted and discussed.

Chapter Five: Conclusions and Recommendations

The final chapter consisted of a review of the entire study, conclusions with regard to the theoretical and empirical objectives, recommendations emanating from the study as well as some proposals for future research

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

Research shows that the introduction and evolution of technology has created new trends that otherwise would not have been preconceived if it were not for the existence of such a phenomenon. Smith *et al.* (2015) agree with this notion. Other researchers have also observed that the use of technology like mobile devices has changed the pedagogical and curriculum approaches in the education sector (Chigona *et al.*, 2009; Mikre, 2011; Tezci, 2009; Towey *et al.*, 2016). However, due to the evolution and unexpected penetration of mobile technology in the education sector today, researchers are yet to establish the extent to which this phenomenon effectively addresses the deficiencies of the already existing education standards (Chin, 2014).

This chapter, therefore, addresses some of the key concepts in this research. The first section (2.2) addresses various existing ICTs in the education sector and how such technologies have spear headed the innovativeness in this field. The second section (2.3) follows by addressing a game-based learning approach in relation to serious games in education. This section illuminates on how serious games and a game-based approach have generally been a useful tool in addressing some of the educational challenges in educational domains. The last section (2.4) addresses some of the challenges that are faced by novice programming learners and how mobile devices have been used to address some of the issues.

2.2 Information Communication Technologies (ICTs) in education

It is not easy to describe ICTs in a single context, as different terminologies have been assumed in relation to digital technology with regard to human learning, such as ICT in education, educational computing and e-learning (Chan *et al.*, 2006). These technologies consist of hardware, software, networks, storage, processing transmission and presentation of information (Tinio, 2003; Wagner *et al.*, 2005). Tinio (2003) has defined ICTs as a collection of various technologies that are used to collect, disseminate and store information. On the other hand, SanNicolas-Rocca and Parrish (2013) describe ICTs as the core of the communication infrastructure such as

telecommunications technologies and digital technologies. Hennessy *et al.* (2010) further concurs that ICTs, as an umbrella term, suggest a collection of applications or communication devices such as radios, televisions and computers. Therefore, ICTs in education can be considered as incorporation of relevant technologies beneficial to the educational process for teachers and learners alike (Livingstone, 2012).

ICTs have affected various sectors and the education sector is no exception (Mikre, 2011; Tezci, 2009). Towey *et al.* (2016) further elaborates that ICTs that exist today have enabled a free and easy way of consuming and managing the necessary information as needed. Haddad and Jurich (2002) point out that education needs transformation, as it is likely to become an activity rather than a location. This may be so as ICTs have positively demonstrated to improve the way information is delivered, received and processed by teachers and learners respectively (Noor-UI-Amin, 2013). Livingstone (2012) suggests that ICTs have the unique ability to integrate traditionally separated educational technologies. These technologies improve the teaching and learning process as they enable students and teachers to be active participants with the learning process (Tinio, 2003). Further to the use of ICTs in education has increased students' motivation and improves understanding, promote active, collaborative and lifelong learning. Additionally, they offer shared working resources, better access to information, and they assist students to think and communicate creatively (Jimoyiannis & Komis, 2007). ICTs have positively demonstrated to be a solution for education, especially in developing countries as such technologies and infrastructure promise to minimise isolation and open a gateway to knowledge in innovative ways (Cunningham, 2015; Tinio, 2003; Tal *et al.*, 2016).

Not only has ICT, such as mobile technology, made it easy to access information, it has also undoubtedly created an innovative learning platform for students especially those that might be regarded as the technology native generation (Towey, Ricky, & Wang, 2016). The idea of using mobile devices for learning is attractive to researchers as this technology is prevalent amongst the young generation (Chigona *et al.*, 2009; Towey *et al.*, 2016). It also enables the learner to acquire lessons from any place at any time (Boyinbode & Ng'ambi, 2013; Stanton & Ophoff, 2013). Su and Cheng (2015)

describe this phenomenon of interacting with these ubiquitous devices for learning as mobile learning. Redd and Schmidt (2011) also add that mobile devices have become a favourable technology to consider for educating learners as the technology itself is also rapidly developing. Hsu *et al.* (2016) further agree that the prevalence of digital resources, such as mobile devices and mobile applications, has opened new avenues in digital learning. Bidarra *et al.* (2015) also suggest that it is crucial to consider the integration of digital media and mobile devices to fully exploit this phenomenon. These mobile devices are convenient for a 21st century learner as they enable learners to acquire cognitive skills such as critical thinking, creativity and problem solving (Towey *et al.*, 2016).

2.3 A Game-based approach in education and Serious Games

Research has indicated that the use of games during the learning process result in positive effects for teachers and learners alike (Yousef *et al.*, 2014). Bodnar and Clark (2017) agree with this notion as they state that games can be one of the effective methods that enable learners to fully immerse themselves in the learning process thereby giving them a better chance of retaining the content. Hsu *et al.* (2016) also agree with this point of view as they further suggest that a game play approach may help learners become autonomous thereby enabling them to easily achieve their objectives. This may be so as games can provide lessons without causing a lot of stress and they also can provide instant feedback to learners (Bodnar & Clark, 2017). A game play approach might therefore be considered a powerful learning tool as it easily motivates students through fun factors such as entertainment, challenges and instant feedback through the game environment (Sierra *et al.*, 2016). In addition, Pho and Dinscore (2015) agree on the positive learning effects these fun factor elements from games have on learners as it allows them to incrementally learn new concepts and help guide them to reach their end goal.

Ebner and Holzinger (2007) highlight the importance a game play approach has for higher education learners as this approach encompasses useful attributes in relation to problem solving. Due to this highly sought out attribute in higher education, this approach is well suited for education domains where skills such as critical thinking,

group communication and decision making are a must (Pivec, 2007). Sierra *et al.* (2016) state that the role a game play approach plays for students as it allows them to handle new knowledge and complex skills by scaffolding the learning process. Therefore, a game-based approach seems like a highly probable and suitable approach for science education domains as opposed to education domains with an expository text-based approach (Sin *et al.*, 2017).

Sørensen (2009) observed that there are game attributes that researchers have pinpointed and consider them crucial elements in respect to pedagogy and these are:

- *Interactivity* – This characteristic refers to the interactivity between players and the interface or other players.
- *Strong identities* – This attribute refers to the virtual character that is associated with the player within the game. The identity is associated with goals, skills and functions that a player must execute within the game.
- *Well-ordered problems* – This attribute allows for well-designed levels within the game. This enables the game to have a unique and seamless flow between levels.
- *Games are pleasantly frustrating* – This characteristic is associated with the level of feedback players acquire from the game. This allows for the game to feel like a challenge for players with regard to one's level of mastery of the game.
- *Cycle of expertise* – This attribute determines how well a game is designed as good games are regarded to have repeated cycles that allow players to master and perfect their skill levels of the game.
- *Deep and fair* – This attribute suggests that a good game is deep when it allows for a player to have an easy game but with gradual levels of difficulty throughout the game and it is considered fair when it is challenging but allows for a player to succeed in the end.

2.3.1 Serious Games

The use of mobile device as a form of entertainment through mobile games has increasingly become the norm amongst the population (Su & Cheng, 2015). This is of

no surprise as the young generation is mostly made up of technology savvy people (Towey *et al.*, 2016). Therefore, it is only natural when researchers considered the use of serious games to address educational challenges faced by learners from such a generation (Zyda, 2005).

Perrotta *et al.* (2013) state that the term related to serious games generally describes the use of video games to enhance the teaching and learning process. However, by definition, it is said the term mostly emphasises on the type of game play that has a clear set of learning objectives (Plass *et al.*, 2015). But researchers agree that this concept ultimately suggests an incorporation of games or game elements with the purpose of enticing and engaging the learner (Djaouti *et al.*, 2011; Pho & Dinscore, 2015; Yousef *et al.*, 2014). Various professional fields such as the military, health care, engineering, politics and education have adopted the serious game phenomenon (Fitchat & Jordaan, 2016). Further to that, Fitchat and Jordaan (2016) suggest that the developers that are responsible for coming up with serious games should always find the equilibrium between the learning objectives and the fun aspect of the game play.

De Villiers and Blignaut, (2016) state that the concept of taking a playful approach for the purposes of enhancing the education process is well established. Further to that, game elements such as score and challenge, interactivity and rewards help solidify the serious games concept in the process of enhancing the education process (Vogel *et al.*, 2006). This has allowed serious games as a concept to become popular among educators as the process has easily demonstrated that it motivates learners by seamlessly integrating learning and entertainment through a unique user experience (De Villiers & Blignaut, 2016). Charsky (2010) further elaborates that serious games enable learners to critically gain a useful lesson that may go beyond the arbitrary features of learning and entertainment.

De Villiers and Blignaut (2016) stipulate that serious games are a perfect teaching conduit as this concept not only allows learners to learn through a fun approach but it also allows them to learn by doing. This further grounds and tailors the purpose of this

game play approach by allowing learners to acquire relevant problem solving skills (Ribeiro *et al.*, 2013).

Nonetheless, there are still contradicting views amongst researchers on the degree at which serious games has affected the education sector. Facer *et al.* (2004) argue that the playful and entertaining element of serious games have become more of a distraction than an enhancement in the education sector. But, Rooney *et al.* (2009) suggest that there are several game dynamics one experiences, either a game embodies behavioural learning principles in which the learning process of various skills and competencies is acquired through engaging and interactive feedback or the learning process is acquired in a constructivist manner by means of pedagogical techniques such as experimental learning, problem-based learning and situated learning.

Perrotta *et al.* (2013) suggest how video games have played an important role in the implementation of serious games. This deserves some consideration and as such technology has become a cultural phenomenon on a global scale in recent years (Bulander, 2010). Video games have played a constructive and educative role to the young generation in all age aspects (Janarthanan, 2012). Further to that, Bulander (2010) state that serious games fall in one or several of the following video game genres:

- *Action game* - The main objectives of these games are centred on physical challenges, for example shooting games.
- *Adventure game* - This type of game allows the player to assume a character in which he/she explore the game's story line through manipulating and interacting with the game character.
- *Role playing game* - These are computer games in which players assume the role of an avatar in a virtual reality setting.
- *Strategy game* - These games allow the player to think critically in decision making if they want to attain a favourable outcome.
- *Puzzle game* - Players are required to solve puzzles in these types of computer games.

- *Simulation game* - This type of computer game assimilates a real world like setting that a player engages in. A very good example is a flight simulator.

Rouillard *et al.* (2014) state that there are two classes of serious games to consider and these are complex serious games and simple mobile serious games. The former requires a development approach from a specialised workforce. Greitzer *et al.* (2007) further elaborate that complex serious games usually take a longer period to develop due to their specialised and sophisticated nature.

Greitzer *et al.* (2007) point to features that distinguish complex serious games due to their sophisticated nature that demand a mixture of difficult challenges to intervene and support each other. These features are listed below:

- *Levelling up* – This implies that a player moves from one level to the next. This signifies an accomplishment and a degree of mastery of the game with regard to the completed level.
- *Adaptability* – Complex games have the unique ability to adapt to a player's skill with regard to the level of difficulty of the game. This unique ability allows the game to ever challenge the player at each level as the player transcends from a comfort game playing zone.
- *Clear and worthwhile goals* – Another feature associated with complex games is having a clear and worthwhile goal. This means that it is important for the game to have a goal the player can look up to in the hopes of accomplishing it. The goal might be short, medium or long term. With a clear goal, the players immerse themselves into the game especially when there is more than one way to solve the problem at hand.
- *Interactions with other players* – The level of interaction between players within the game also drives complex. Players may have a unique experience based on how well they communicate and interact with other players in the game to achieve their primary objective.
- *Shared experiences* – The last feature of a complex game is the shared experiences of players in the game. This feature is especially crucial for

experienced game players as it allows them to share their unique experiences with other players, based on the likes and dislikes of the elements of the game.

Rouillard *et al.* (2014) explain that the simpler mobile serious games usually take an alternative approach in their design and implementation. They have a light design approach as they are usually played in short sessions. Kurkovsky (2013) also attests to this, as mobile devices are ubiquitous and the idea of using mobile games to entice learners is highly probable as this may give the learner instant gratification.

It is important, however, to make sure that the balance between the pedagogy and the game play aspect of a serious game are carefully implemented to have the right amount of work for the right amount fun (De Villiers & Blignaut, 2016). However, Backlund *et al.* (2008) suggest that this rule of thumb may be difficult to follow when the problem to be addressed is supposed to be non-entertaining in nature. Nonetheless, the research community has shown great determination in finding ways in which serious games can be used to effectively address appropriate educational deficiencies for its intended learners (Bellotti *et al.*, 2009).

2.3.2 Serious Games in Education

The serious games phenomena have proven itself to be an integral part of enhancing the teaching and learning process for both tutors and learners, respectively. De Jans *et al.* (2017) agree on the prevalence of serious games and how they have proven to be important in complementing these teaching and learning processes for various education sectors. With regard to such phenomena, it is anticipated that current educational methods that exist are bound to change as both learners and technology advancements may dictate how information is consumed (Wang & Tseng, 2014). Noting this, it may be predicted that in the next decade, a game-based learning approach may become the norm not only because learners and technology demand it, but education institutions require it as these institutions also look for better ways of teaching and disseminating information (Callaghan *et al.*, 2015; Krassman *et al.*, 2015).

Serious games have been used to address problems in various areas for the education sector. To mention just a few, they have been used to address issues in different domains such as health care, mathematics, science and technology, engineering, project management, economics, history and literature (Serrano-Laguna *et al.*, 2017; Marquez-Tellez *et al.*, 2017; Mavridis *et al.*, 2012). These serious games are used to address the assorted problems for different groups of people. For instance, Khaleel *et al.* (2015) point out that students have a hard time grasping concepts from technical subjects when it comes to higher education. Noting this, serious games seem to provide the required remedy for this problem as it minimises the level of boredom for the learners in such subjects (Pranantha *et al.*, 2012; Khaleel *et al.*, 2015; Mbogo *et al.*, 2014).

Previous studies have indicated the importance of the fun factor that is brought about using serious games. Wang and Tseng (2014) further confirms this observation as they suggest that the playful element in serious games strongly motivates learners and this in turn yields positive results in terms of learning. Additionally, the nature of these games is well suited for these current learners as most of them are digital natives which enable them to easily adapt to new skills and information through this process (Krassman *et al.*, 2015).

Bloom's taxonomy has been applied by researchers in an attempt to understand the relationship between serious game design and the intended objective with regard to learning by play (Lameras, 2015). Mohd *et al.* (2018) further collaborate on this approach as they highlight the relationship between game and learning attributes in line with learning theories such as cognitivism and constructivism. Parise and Crosina, (2012) further emphasise on how computer games are well aligned with a constructivist learning model as learners become active participants through exploration and problem-solving. However, Schmitz *et al.* (2013) stipulate on Bloom's six cognitive domains which are knowledge, comprehension, application in new situations, analysis synthesis, and evaluation and how these domains have provided a foundation for serious game designers with regard to mapping learning outcomes and game attributes. This appears to be in line with education on an undergraduate

level, as students are required to acquire computing competencies based on their cognitive levels of knowledge, comprehension and application in accordance with Bloom's taxonomy of learning objectives (Battistella & von Wangenheim, 2016). Table 2-1 lists gaming attributes that align with the intended learning outcome as per Bloom's taxonomy:

Table 2-1: Bloom's taxonomy and game attributes

Learning Attribute	Game Attribute
Information transmission	Task description; multiple choices to select, content description, challenge repetition, scoring
Collaborative	Role-playing, community collaboration, epic meaning, bonuses, contest, scoring, timers, coins, inventories, leader boards, communal discovery; game levels
Discussion and argumentation	Nested dialogues, NPC (Non-Playable Character) interaction, in-game chats; game levels, research track, maps; progress tress
Individual	Game journal, missions, objective cards, storytelling, dialogues, puzzles, branch tasks, research points, study requirements, game levels

(adopted from Lamas, 2015)

Table 2.1 illustrates game attributes that are in line with Blooms taxonomy. It may be noted that learning objectives vary from information transmission to individual learning. As such, various game attributes are required to address these different levels and needs of learning.

It is important to understand the need that serious game designers have when it comes to applying appropriate frameworks with regard to designing and developing serious games and mapping gaming attributes with the required learning outcomes (Heintz & Law, 2018). Such a framework, however, can be identified from the research studies done by Wilson *et al.* (2009) and Bedwell *et al.* (2012). These frameworks outline characteristics and elements that are associated with identifying and creating a serious game as research proves that these elements enable designers to come up with well-tailored serious games (Heintz & Law, 2018; Mohd *et al.*, 2018). Despite all this however, it is apparent how there is a disparity between end users and the existing serious games as there is lack of correlation from the designer with regard to the end

product, thereby creating a problem for users when left to choose and pick a suitable serious game as per their needs (Göbel, 2016). In that regard, Lamerás (2015) suggest that evaluating the effects of learning using serious games is important as this may provide empirical evidence on mapping the game elements to learning despite existing developed taxonomies put in place to address this challenge. Schmitz *et al.* (2013) concur as they further discuss the lack of extensive empirical evidence with regard to mobile learning games and their learning outcomes. Table 2-2 illustrates the gaming attributes crucial for serious games as depicted by Heintz and Law (2018):

Table 2-2: Game attributes in line with serious games

Category	Game Features (deemed to support learning)
Action Language	Language/Communication: textual or verbal
Assessment	Assessment: feedback to learn from previous actions Progress: players progress towards the end of the game
Conflict/Challenge	Adaption: adjust the difficulty to the skill level of player Challenge: progressive, well balanced difficulty + clear goals Conflict: solvable problems Surprise: random element of the game
Control	Control: player's power or influence over elements in game Interaction (Equipment): game responds to the player's action
Environment	Location: physical or virtual world the game takes place in
Game Fiction	Fantasy: make-believe, i.e. take on the role or simulate process Mystery: sensory or cognitive curiosity to obtain information
Human Interaction	Interaction (Interpersonal): competition, acknowledgement Interaction (Social): activity shared with others
Immersion	Pieces or Players: objects or people included in the narrative Representation: perception of game reality, enables focus Sensory Stimuli: temporary acceptance of an alternate reality Safety: no consequences other than possibly losing
Rules/Goals	Rules/Goals: criteria of how to win; need to be well-defined

(adopted from Heintz & Law, 2018)

Table 2-2 illustrates some of the identified game features that are important for serious games and their design. Depending on the required game design specifications and learning objectives, a combination of these game attributes may be used to highlight and deliver these key features.

There are two distinct approaches that are commonly used to enhance the higher learning process through serious games. The first one is by using a commercial off the shelf product and the second one is through designing a tailored game to the problem at hand (Pranantha *et al.*, 2012). However, Rooney *et al.* (2009) argues that despite both techniques having their upside and downside, the use of tailored games is still a challenge as there is a need for more resources to develop such games.

2.3.3 Appropriate Serious Games Evaluation Methods

It is imperative to have effective evaluation methods for serious games. Mayer *et al.* (2014) highlights this as they researched on evaluation techniques of serious games. However, this study focused on evaluation of the serious games with regard to its usefulness and intended learning outcome for the user. Pourabdollahian *et al.* (2012) point out that it is very important to consider the evaluation of serious games for their purpose and learning context. The researchers further point out some of the existing evaluation techniques from the literature and these are listed in Table 2.3:

Table 2-3: Serious games evaluation methods

Researchers Name	Framework
de Freitas and Oliver (2006)	Four -Dimensional Framework
Amory (2006)	Game Object Model version 2
Kiili (2005)	Experiential Gaming Model
Egenfeldt Nielsen, Simon (2003)	Learning environment, personal learning factor, learning outcome
Garris et al., (2002)	Game Based Learning model
Hu (2008)	Adventure Game Framework
Wouters et al., (2008)	Learning outcomes taxonomy
Karoulis and Demetriadis (2005)	Motivational matrix

Malone and Lepper (1987)	Design Heuristic for Motivating Instructional Environment
Hainey (2010)	Game Based Learning

(adopted from Pourabdollahian *et al.*, 2012)

Table 2.3 lists some of the serious game evaluation techniques found in the literature. Pourabdollahian *et al.* (2012) point out that de Freitas and Olivier (2006) demonstrate an evaluation framework that focuses on the effectiveness of the serious game from a tutor's perspective. The four-dimensional framework is of significant interest as researchers have concurred on the need for better evaluation techniques but more so for the ones that can assist educators and tutors specifically (Abdellatif *et al.*, 2018; de Freitas & Olivier, 2006).

To further clarify on the elements of this framework, Prinsloo and Jordaan (2014) highlight the following four elements:

- Context: This attribute addresses the learning aspect of the serious game. It focuses on a particular learning area such as science or history, for example.
- Learner specification: This attribute focuses on whether the serious game is based on individual or group learner specifications.
- Mode of presentation: This attribute focuses on the fidelity and immersive aspects of the serious game.
- Pedagogic principles: This aspect requires the lecturer's knowledge of the learning objectives.

But to further understand the Four-Dimension framework, the researchers summarised the purpose of the framework as follows (Prinsloo & Jordaan, 2014):

- To aid educators with regard to selecting appropriate serious games in the learning environment.
- To assist educators in evaluating serious games.
- To assist researchers in evaluating serious games.
- To help serious game designers in mapping gaming attributes for their intended learning outcomes.

However, Petri and von Wangenheim (2016) note that the majority of the existing evaluation frameworks have a broad spectrum as they lack instructions on how to conduct such evaluations, data collection and analysis.

2.3.4 Serious Games in Programming

Nunes *et al.* (2016) state that several researchers have attempted to use serious games to help computer science learners in programming with a positive outcome. Sierra *et al.* (2016) concur as they suggest that literature exists in the exploration of games used as a tool to help learners to improve in programming. For example, Mitamura *et al.* (2012) investigates serious games on learning programming through a concept called “Learning programming through gaming.” They developed a series of games that help students in learning Java programming. On the other hand, Greitzer *et al.* (2007) investigates cognitive principles and how they can be used in serious games to improve the effectiveness of cyber security. The research involved an investigation of a serious game called “Cyber Siege”, that allows a player to interact with a virtual laboratory with the primary objective of training him/her in cyber security principles. However, it is argued that there may be a need for more research to be done with regard to science games as there is a desire to attain a better understanding of the role games take in science learning (Bressler & Bodzin, 2013).

There are pre-existing games that have been developed with regard to teaching players basic programming skills (Jordine *et al.*, 2015). The researchers further categorise programming learning games that were specifically designed for Personal Computers (PCs) and those that were designed for mobile devices. For instance, a serious game such as “Karel the Robot” was designed for the desktop platform and this game was created to teach players Java or C++ programming. Another similar game in this category is “Alice” which allows players to solve programming related problems through a series of puzzles (Coelho *et al.*, 2011; Jordine *et al.*, 2015). Lastly, “PlayLogo3D” is another serious game in this category and it is a game that teaches programming principles through a simple and playful programming language called “LOGO”. Jordine *et al.* (2015) stipulate that such serious games are now possible to play through mobile devices due to the emergence of Hypertext Markup Language

(HTML) and Cascading Style Sheets (CSS). Please refer to Appendix A for more examples.

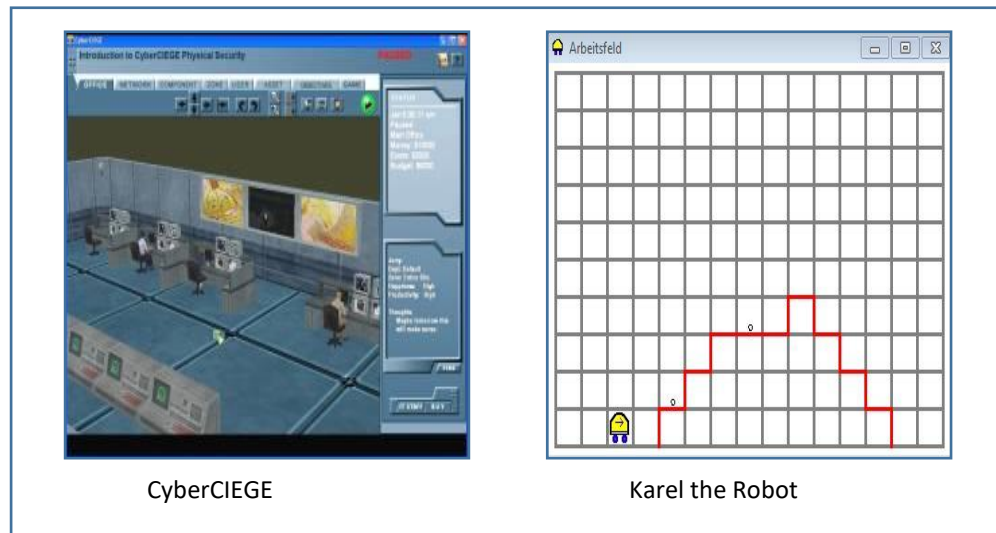


Figure 2-1: Image of Serious games in programming

Figure 2-1 illustrates Cyber Siege and Karel the Robot. These are some of the games that have been designed to help players learn computer programming fundamentals through game play.

Tsalikidis and Palvidis (2016) further elaborate on some of the well-known initiatives that have come into existence due to the academic research performed in the serious game area concerning learning and teaching programming. These initiatives are:

- Code.org – this is a non-profit foundation based in the United States. It is an online platform that is used to encourage students in learning programming through games.
- CodeCombat.org – this is another platform that was accidentally developed by George Saines as he attempted to teach himself coding. This later became a significant move in the Learn By Code movement.

- **Code Spells** – this project spawned from the PhD research of Sarah Esper and Stephen Foster at the university of San Diego which aimed at teaching kids how to code. It is still an ongoing project that is focused on creating an immersive and visually appealing gaming platform for both adults and children.
- **Codehunt** – this a serious game design in which a player must find and assemble missing code.
- **Code Warriors** – this serious game platform takes on a player from a novice level to an advanced level by implementing JavaScript in virtual battle scenarios with robots.

2.3.4.1 Game engines

A game engine is described as a game development framework that is used to create core game functionality by providing the necessary tools and game structure (Schuetz, 2018). There are various game engines that are used by game designers and developers. An engine might either be used to exclusively design an HTML based game while a cross platform engine targets multiple gaming platforms (“Facebook for developers”, n.d). Below is a brief description of some of the common game engines used:

2.3.4.1.1 HTML5 Engines

- *Phaser* - Davey, (2017) describes Phaser as a fun, free and fast 2D framework used for creating HTML5 games for desktop and mobile browsers.
- *PixiJS* – this is an HTML5 framework that fully supports WebGL. It is used to create interactive gaming content.

- *Game Pencil Engine* - this is a dynamic tool used for gaming design for various platforms such as Windows, Mac OS and Linux.
- *ImpactJS* – this is a JavaScript based platform used for creating HTML5 games for mobile and desktop browsers (Szablewski, 2017).
- *CreateJS* – Skinner, (2017) states that this is a collection of modular libraries that are used collectively or independently to make interactive gaming content for web technologies through HTML5.
- *GameMaker* – this is a cross platform tool that is used to design and develop various and assorted video games. It uses a drag and drop game design and development approach that requires little or no programming expertise (Vinciguerra, & Howell, 2015).
- *PlayCanvas* – this is a 3D based HTML5 game engine. It is a server-side application that does not require installation to a PC.
- *BabylonJS* – this is another 3D game engine used for HTML game design.
- *Construct3* – it is an HTML5 game engine that does not require any programming skills as the designer simply uses an event-based approach when designing and developing a game.

- *Layabox* – this is another HTML5 game engine that supports both 2D and 3D game designs. It uses both JavaScript and ActionScript (AS) AS3 as programming languages for game development.

2.3.4.1.2 Cross Platform Engines

- *Unity* – Sinicki (2018) explains how Unity is a cross-platform 3D engine with a user-friendly design and preferred by novice game designers while still offering professional game design tools. On the other hand, Schuetz (2018) agrees and states that Unity is an integrated development framework that allows game designers to address complex game functionality while delivering rich solutions. Schuetz (2018) further elaborates that Unity is one of the most popular cross-platform engines globally.

There are certain advantages that game designers experience when developing and designing games (Schuetz, 2018). These advantages are listed below:

- Unity supports multiple platforms such as iOS, Android, Nintendo Switch and Switch.
- Unity has a powerful graphical engine that is compatible with multiple devices.
- It supports C# and JavaScript as its programming language.
- It is equipped with a drag and drop interface.
- It also has extensive support and adequate documentation due to the large community of developers that are active with the platform.
- It also supports both 2D and 3D game design.

The Unity game engine has some drawbacks, which are pointed out by Schuetz (2018):

- The researcher points out that getting acquainted with the platform's features and capabilities can sometimes be challenging.
 - He also states that beginners become intimidated due to the complexity of the engine.
 - On the other hand, optimising graphically intensive games becomes a difficult task.
 - Integrating mobile Application Program Interface (APIs) is harder by comparison to other game engines.
- *Unreal* – this is a cross-platform game engine that is considered to be a complete package of design tools that have been created to meet a designer's artistic vision ("Unreal Engine", n.d). But Schuetz (2018) states that Unreal is one of the most popular game engines used by game designers, professional or otherwise, as it makes a convenient game design tool for first-person shooters, Role Playing Games (RPGs), fighting and stealth games.

There are pros and cons for using this game engine though (Shuetz, 2018). Below is a list of the pros associated with this game engine:

- One of the advantages of using this game engine is that it incorporates a profiler in the default version.
- It has better graphical tools in comparison to other game engines.
- Its asset store has some well-designed game templates.

Some of the disadvantages coupled with the use of this engine are:

- It uses C++ as its game development programming language and this language requires extensive programming experience.
- It has a few third-party API as compared to other game engines.

- Most of its builds are not well suited for regular devices with standard graphic capabilities.
- *Cocos* – this is another cross-platform engine popular with many game developers. It is also regarded as open-source because developers commonly use these (“What is COCOS2D-X”, n.d).
- *Defold* - this is described as a cross-platform engine and professional game development platform that is used by developers to create HTML5 games (“Defold”, n.d).

2.4 Learning Programming and Mobile Devices

This section addresses literature on the challenges that are faced by novice programmers and how mobile devices and technology has been used to address such issues.

2.4.1 Novice Learners and Programming

It has been observed that undergraduate students have problems in learning programming (Mbongo *et al.*, 2013). Coelho *et al.* (2011) stipulate that a decline trend in computer science majors has also been noticed as students suggest having low motivation towards this field as they find subjects such as programming difficult to comprehend. Gomes *et al.* (2010) also agree with this notion as research further indicates high failure rates in programming courses. The sentiment of a decline in the number of student enrolment in computer science is shared amongst these researchers (Coelho *et al.*, 2011; Mbongo *et al.*, 2013; Gomes *et al.*, 2010). This trend has been observed in many countries as statistics suggest that more than 50% of students who initially enrol in a computer science major soon decide to drop out of the field (Muratet *et al.*, 2011). Fesakis *et al.* (2009) further elaborate that students decide to opt out of computer science majors as they find it difficult to grasp the basics behind programming and this is something to be concerned with as computer science is an important field in the 21st century.

Despite these difficulties, there has not been a consensus on an effective way for teaching students who are struggling with these computer science majors (Apiola & Tedre, 2012). Nonetheless, there have been several tactics that have been suggested to tackle this problem, like the development of programming languages to make the learning process more interesting, researching in alternative pedagogical approaches and the study of alternative environments suitable for learning and practising programming for a 21st century learner (Fesakis *et al.*, 2009). However, Gomes *et al.* (2010) suggest that students might find it easier to learn programming if teachers assumed a leading approach in teaching by becoming more involved in discussing student related problems with regard to programming comprehension.

Coelho *et al.* (2011) state that noting the problem faced by students in these computer science majors; researchers have resulted to experimenting with video games with the hopes of enticing these students back into programming lessons. Sierra *et al.* (2016) concur and further suggest that most researchers have observed positive results with video games as a potential tool for mastering programming skills since such tasks mostly require constant hands-on practice and cognitive skills which, coincidentally, is something that is acquired by playing games.

2.4.2 Basic Programming concepts

There are various programming languages at the disposal of programmers and as much as they are all different, they all have underlying concepts that they all share (Page, 2012). Mukit (2018) describes a programming language as a set of instructions that carry out a predefined task by a computer. The nature of such instructions is usually monotonous, machine centric, highly accurate and requires high speed (“Basic Programming Concepts”, 2005; Ching, 2017).

Mukit (2018) suggests that there are two different programming models namely structured programming and object-oriented programming. The former has a sequential approach when the code is executed. This is done so as it is meant to

improve clarity, quality and development time of the actual block of code. On the other hand, the latter does not follow a sequential flow of code execution as objects in the code can freely interact with one another by passing messages.

Programming concepts vary based on the programming language of choice. However, experts mention the following as common concepts, and these are programme structures, variable declaration, looping structures, control structures and syntax (Marshall & Stephaine, 2018; Page, 2012; Mukit, 2018).

2.4.2.1 Programme structures

Mukit (2018) state that a programme structure can be considered well or poorly structured and it is described as the way a programme and its components align with each other.

Structured programmes share a set of relatable attributes and these are statements that initiate the programme, variable declaration and blocks of code (Mukit, 2018). It is crucial to have the right sequence of commands as this allows for a well-structured piece of code (“Computer Basics”, 2014).

2.4.2.2 Variable Declaration

Page (2012) describes a variable as a container used to store information that is critical to the functionality of a programme. Variables store assorted data types based on the programme’s preference. Mukit (2018) states that there are different types of variables and these are integers – used to store number, real – used to store fractional numbers, character – used to store a single letter and string – used to store multiple letters.

2.4.2.3 Looping Structures

Marshall & Chris (2000) point out that a set of instructions designed to repeat based on a prescribed condition is referred to as a loop. These pieces of code

are designed to repeat a task a certain amount of times until the set condition becomes false (Mukit, 2018).

2.4.2.4 Control Structures

Mukit (2018) states that a control structure is a list of programme instructions that enable a programme to make decisions based on the conditions set. Typical control structures in most programming languages are if...else structures and while...loops (Page, 2012).

2.4.2.5 Syntax

Page (2012) describes syntax as a way that the set of programming instructions are written by the programmer. To be more specific, these are rules that define a unique set of symbols that are correctly structured programmes in that language (Mukit, 2018).

2.4.3 Learning Programming through Mobile Devices

Mbogo *et al.* (2014) state that several applications are used to learn programming through mobile devices. However, another study by (Kurkovsky, 2013) suggests that students may learn programming skills much quicker if they engage with design tools that focus on developing mobile games. Maleko (2014) further stipulates that there have been more positive outcomes when these mobile devices are integrated with technologies such as Facebook while using its unique features for discussions, chats and brainstorming sessions. Mbogo *et al.* (2014) also suggest other mobile programming tools that are used for learning programming such as Mobiedv, TouchDevelop by Microsoft and Massachusetts Institute of Technology (MIT)'s App inventor.

Considering the recent trends since the inception of Web 2.0, there has been an emerging popularity of using social media (APIs) by most developers. The most

common of these APIs are the Facebook platform and OpenSocial platform. Google designed the latter while Facebook designed the former (Ahmed & Shaikh, 2011).

Ahmed and Shaikh (2011) state that the Facebook platform is a set of tools and services designed by Facebook that are used by third party developers to create their own applications that are accessible via Facebook. The platform is comprised of the following tools:

- Facebook API: This enables third party developers to have access to user information on Facebook.
- Facebook Query Language: This enables third party users to query user information from Facebook.
- Facebook mark-up language and Facebook JavaScript: This enables third party developers to basically build their Facebook application.

On the other hand, OpenSocial is a framework designed to integrate various social application platforms, which are operated by different individuals and organisations, into a seamless and unified ecosystem (Mitchell-Wong *et al.*, 2007). Häsel (2011) states that OpenSocial applications originate from Google's gadget architecture and they are built on standard web technologies such as HTML and JavaScript. The inception of the OpenSocial platform was created to address compatibility issues faced by different social media platforms. Firstly, it was designed to help social media platform developers in eliminating the need to rename or recreate one's API and secondly, to enable them to have a unified platform on which any social media gadget or application may operate (Bogdanov *et al.*, 2011).

App Inventor (AI) is a web-based tool that comprises of two distinct features which are the component designer and the block editor (Hsu *et al.*, 2016). Spertus *et al.* (2010) state that AI is a Google creation for the android platform, and it is used as a visual programming tool for creating mobile applications for individuals who are not professional programmers. This mobile development application platform was later transferred from the Google labs project to Massachusetts Institute of Technology

(MIT) where it has since then been managed (Morelli *et al.*, 2011). Wolber (2011) further concurs with Hsu *et al.* (2016), that AI has two main components namely the component designer and the Block editor. The former is used for building user interfaces while the latter is used for defining application behaviour (Wolber, 2011). AI equips a developer with building blocks that can be utilised for any purpose or goal (Pokress & Veiga, 2013). The visual programming aspect of AI makes it a very powerful development tool as a developer may be able to drag-and-drop, organise assorted interfaces and non-visible components, and behaviour logic blocks when making a viable mobile application (Hsu *et al.*, 2016).

2.5 Conclusion

This chapter has looked at the associated and important key concepts of this research namely ICTs in education, game-based approaches in relation to serious games in education and learning to programme through mobile devices. Under ICTs in education, the relationship between the uses of ICT to enhance education was discussed. Secondly, the relationship between game-based approaches was also addressed. Serious games and their attributes were also addressed in this chapter in relation to their effects in the education sector. The last section of this chapter addressed novice learners in programming and how mobile devices have been used to solve some of the challenges faced by these novice learners.

CHAPTER THREE: RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

The primary objective of this research was to identify and use selection criteria for a serious game to assist students in learning programming concepts. To achieve this, a discussion of the existing literature on a suitable research methodology and Action Research (AR) is necessary. Saunders *et al.* (2009) describe the research methodology as a concept that is adopted during the research process. Research is conducted when a subject is augmented with new knowledge (Mouton, 2001). Marczyk *et al.* (2005) further stipulate that research should be viewed as the foundation for scientific progress. Scientific research occurs only when knowledge is produced (Neuman, 2011). Straub *et al.* (1994) state that the primary criterion for the publication of research is that it must contribute to the body of knowledge. The researcher must carefully select research methods and techniques and the significance of the systematic approach towards the research process is emphasised by Saunders *et al.* (2009).

Many methods are available to obtain new knowledge. Susman and Evered (1978) outline that AR is one method and it focuses on diagnosing, action planning, action taking and evaluating of research problem areas. Riel (2010) also explain that AR should be viewed as a coordination, in-depth understanding of one's actions, and the effects of these actions, in various places such as an office, organisation or community. AR is considered as an appropriate approach for researchers that have intentions of improving a particular situation (Maheshwari, 2012). This makes AR an ideal approach for tackling problems where researchers do not fully understand the nature of the intended problem and the organisation or community consequentially may also not appreciate the proposed solution (Blake, 2010).

Therefore, this chapter aims to demonstrate an understanding of research methodologies and it also aims to position this study in a research framework. It starts with a general discussion of research philosophies, paradigms and methods followed

by a discussion of AR. The formulation of the research approach and the process of this study conclude the chapter.

The chapter is divided into the following sections: research philosophy (3.2); research paradigms (3.3); positioning the study (3.4); action research (3.5); data collection techniques (3.6); research process of this study (3.7); and finally, the conclusion (3.8).

3.2 Research Philosophy

Saunders *et al.* (2009:128) state that research philosophy “relates to the development of knowledge and the nature of that knowledge” and reflects the way the researcher understands the world.

Blanche *et al.* (2006) identify three research philosophical assumptions namely: ontological, epistemological and methodological assumptions and Vaishnavi and Kuechler (2004) identifies axiological as a fourth type of philosophical assumption.

Ontological assumptions are concerned with the nature or form of the research under investigation (Adebesin *et al.*, 2011). Epistemological assumptions are concerned with knowledge that is associated with the focus area of research (Saunders *et al.*, 2009). Methodological assumptions concern the process that enables the researcher to gain knowledge within the field of study (Guba & Lincoln, 1994). Axiological assumptions refer to the researcher’s judgements or beliefs of what is of value in relation to the study (Saunders *et al.*, 2009). To position this study, the following sections discuss research paradigms.

3.3 Research Paradigms

A research paradigm is associated with a philosophical assumption on how research should be carried out (Adebesin *et al.*, 2011). Researchers define a paradigm as a matrix of metaphysics that shape the way people view the world (Kinash, 2006; Guba & Lincoln, 1994). In Information Systems there are four basic research paradigms that

are commonly applied namely, positivism, interpretivism, CST and design research (Goede & De Villiers, 2003; Adebessin *et al.*, 2011).

Table 3-1 is a summary of the research paradigms and their respective philosophical assumptions. The positivist paradigm has an objective stance as its underlining philosophical assumption while the interpretivist paradigm primarily has a subjective stance as its underlining philosophical assumption. However, design science and constructionist/critical social theory may also be regarded as paradigms that have a subjective stance as an underling philosophical assumption. But a clear distinction between these latter two paradigms, as shown in the table 3-1, is that constructionist/critical social theory paradigm requires a great deal of participation from the researcher in both the study and findings while design science requires the creation of a solution according to the researcher's understanding.

Table 3-1: Research paradigms and their philosophical assumptions

(Adapted from Adebessin et al. (2011), Blanche et al. (2006) and Vaishnavi and Kuechler (2004))

Research Paradigms	Philosophical assumptions			
	Ontology	Epistemology	Methodology	Axiology
Positivist	Single, stable-like reality. Law like.	Objective. Detached observer.	Experimental. Quantitative. Hypothesis testing.	Truth (Objective). Prediction
Interpretivist	Multiple realities. Socially constructed.	Empathetic. Observer subjectivity.	Interactional. Interpretation. Qualitative.	Contextual understanding.
Critical social theory / Constructionist	Socially constructed reality. Discourse. Power.	Suspicious. Political. Observer constructing Versions.	Deconstruction. Textual analysis. Discourse analysis.	Inquiry is value bound. Contextual understanding. Researcher's values affect the study.
Design Science Research	Multiple, contextually situated realities.	Knowing through making. Context-based construction.	Developmental. Impact analysis of artefact on composite system	Control. Creation. Understanding.

The different paradigms listed in table 3-1 are discussed in the following sections. Section 3.3.1 outlines details on the Positivism paradigm.

3.3.1 Positivism

Positivism is one of the oldest paradigms adopted in research. Gray (2013) elaborates how dominant it was in the field of social science during the 1930s till the 1960s, and how it focuses on the exclusion and objectivity of the researcher during experiments by means of observation. Positivism is an approach where the researcher does not engage with the experimental subjects but rather gather data by means of observation.

De Villiers (2005) states that a positivist paradigm has a unilateral point of view with regard to the subjects involved and the way knowledge is gathered.

Researchers from this paradigm generally think that reality is objectively given and that it can be understood through a quantifiable approach by means of independent and objective experiments (Myers, 1997). The quantifiable nature of positivism allows for an easy interpretation of the research by statistical means (Saunders, Lewis, Thornhill, & Wang, 2009).

Given the nature of positivism on its stance of knowledge on reality, three basic characteristics are associated with this paradigm in the hopes of achieving unbiased results (Bryant, 2002). These attributes are:

- Methodological procedures of natural sciences that apply to various enquiries.
- Goals of non-natural sciences that are the rules to be lawfully followed.
- Technical character on knowledge and value.

The following section 3.3.2 outlines and discusses the Interpretive paradigm.

3.3.2 Interpretivism

Interpretivism is a paradigm that is generally considered a contrast to positivism. It is inversely related to positivism as its epistemological stance focuses on people and how they behave in their everyday lives (Saunders, Lewis, & Thornhill, 2009). Concurrently, interpretivism states that the various forms of reality demand unique methods of experimental approaches as each reality differs from one another (Gray, 2004). Besides, interpretivism has shown great potential in understanding human behaviour with regard to social and organisational environments; illustrating its relevance in the development and management of information systems (Klein & Myers, 1999).

Klein and Myers (1999) solidify the notion of an interpretivism paradigm and its relevance in the IT field by identifying seven fundamental principles:

- *The fundamental principle of the hermeneutic circle.* The principle states that all human understanding is gained by repeatedly looking at the independent meaning of parts in their entirety. It is, therefore, the basis of all the other principles.
- *The principle of contextualisation.* This principle closely examines the origins of interpretivism and the society to provide an understanding of the whole research process to the interested party.
- *The principle of interaction between the researchers and their subjects.* This principle looks at the interpretation and analysis of data by the researchers with regard to the subjects involved.
- *The principle of abstraction and generalisation.* This principle requires understanding the research findings and the relationship that exists between the set principles based on the subjects' human behaviour.
- *The principle of dialogical reasoning.* This principle suggests the level of critical thinking and rigour that should be involved with regard to the researchers' findings, as it is important that a researcher should criticise his/her own findings to achieve consistency and accuracy.
- *The principle of multiple interpretations.* This principle emphasises the care that should be taken with regard to the interpretation of the research findings as researchers in this paradigm have a subjective approach in conducting the research, analysing the data and interpreting the findings.
- *The principle of suspicion.* This principle suggests that careful considerations should be put in place with regard to data collected from the participants. The researcher should not distort the value of information gathered to appear to be in his/her favour.

The following section 3.3.3 outlines and discusses the Constructionist/Critical Social Theory paradigm.

3.3.3 Constructionists or Critical Social Theory

Constructionists or critical social theory is a paradigm that has an independent view of reality. It is a current form of research that questions the norm in our everyday lives and how this affects people's behaviour (Gray, 2013). Myers (1997) agrees that the sole purpose of any critical research is to analyse that which is regarded as the social norm and eventually focus on such trends and how they affect decision making for people in a society. To put it in perspective, there are certain characteristics that are associated with this paradigm and these are mentioned below (Sudarsan, 1998):

- Critical theory strongly states that there is no absolute subject to knowledge and that the coincidence of the subject and object lies in the future due to social regress where the relationship between the subject and object is refined.
- The method of science is different as the ends define the means, but both the ends and means are considered equal through the process of abduction.
- Critical social theory also highly illuminates on ideology as it is not completely free from the societal framework since it is historically associated with grounded theory.
- Critical social theory regard praxis as an important attribute and it greatly upholds to ideals of freedom, justice and happiness.

The methodology frequently implemented by Information System (IS) constructionists is known as Action Research (AR). Rapoport (1970:499) defines AR as:

“Action research aims to contribute both to the practical concerns of people in an immediate problematic situation and to the goals of social science by joint collaboration within a mutually acceptable ethical framework”.

The following section 3.3.4 outlines and discusses the Design Science Research methodology.

3.3.4 Design Science Research

The Design Science Research (DSR) paradigm creates and evaluates innovative technology artefacts that are intended to identify problems through a rigorous process that makes research contributions through design evaluations and communications of results to appropriate audiences (Pfeffers *et al.*, 2006).

A DSR model addresses important and relevant problems through a series of stages as follows: 1) *Problem identification and motivation* – this stage defines the important and relevant problem of the research and determine the intended solution, 2) *Interpret objectives of a solution* – this stage interprets the relevant solutions derived from objectives attained by defining the research problem, 3) *Design and deployment* – this stage makes an artefact through appropriate design techniques, 4) *Demonstration* – this stage demonstrates an artefact's efficacy intended to solve the problem, 5) *Evaluation* – this stage tests performance of the artefact's support on the intended solution to the problem, and 6) *Communication* – this aspect communicates the problem and its important aspects, the artefact and the design perspectives to the relevant audiences (Hevner *et al.*, 2004).

3.4 Positioning the Study

Appropriate methods are necessary to execute the study. The four paradigms discussed in the previous section are used to position the study. A philosophical position is taken and therefore AR is appropriate as it is important to understand the collaborative process followed, to come up with a selection criterion for a serious game that can assist students to learn computer programming concepts. AR creates an environment that enables participants to be their own researchers, ultimately giving participants control of the research direction, the ability to investigate problems from their own point of view, thereby resulting in emancipation through the pursuit of knowledge and critical reflection (Tandon, 1989).

A discussion of AR is necessary as this study makes extensive use of this paradigm.

3.5 Action Research

AR has been used in the engineering disciplines for some time and is increasingly accepted as a legitimate approach to IS research (Baskerville, 1999). AR is defined as research that creates missing knowledge by means of collaborating with participants in order to bring the needed social change (Maheshwari, 2012). AR addresses problems identified by the researcher with the help from the community or organisation through a series of cycles that reflect on the identified and appropriate solutions (Riel, 2010).

The goals behind a successful AR study entail (Riel, 2010):

- To have a continuous progression in problem solving and an improved professional practice by means of continued learning.
- To gain better knowledge of changes in an organisation through meaningful collaboration.
- To advance a community's goal by means of active participatory action learning or research.

The following sections give an overview of AR which include concepts central to AR; the AR process; AR approaches; and available guidelines for practising and evaluating AR.

3.5.1 Concepts central to AR

It is easy to understand AR when one deconstructs the old ways of doing things and makes an effort in changing those ways (Pretorius *et al.*, 2016). Therefore, this section addresses the nature of AR by highlighting its characteristics in an information system perspective.

Four characteristics that entail information systems action research are (Baskerville, 1999):

- *Comprehension of immediate social situation* – AR needs to enhance an understanding of the immediate social setup. Focus is placed on the varying nature of the said social setup within the information system arena.
- *Increase scientific knowledge and practical problem solving* – Two important output elements created by this characteristic are:
 - Observations are made with high interpretive assumptions.
 - The researcher manages the problem environment.
- *Collaboration* - AR is a participatory methodology that helps to improve the research process for both the researcher and the participant. The social setup is a strong determinant factor with regard to the success of providing the needed balance between the researcher and participants.
- *Change process in a social system* - AR is suitable for research situations meant to understand the change processes within social systems.

However, Baskerville and Wood-Harper, (1998) summarise AR in information systems by identifying four distinctive characteristics and ten distinctive forms shown in Table 3-2:

Table 3-2: Characteristics and forms of action research

(adopted from Baskerville, 1999)

Characteristics	Forms
Primary Goals - Organisational Development - System design - Scientific Knowledge - Training. Typical Involvement - Collaborative - Facilitative – Expert Structure - Rigorous - Fluid Process Model - Iterative – Reflective -Linear	Process Consultation Clinical Field Work Action Learning Participant observation Action Science Multi-view ETHICS Soft Systems Methodology IS prototyping Canonical

The aim of the following section is to discuss AR methodologies within IS research.

3.5.2 AR process

Pretorius *et al.*, (2016) explain that AR is a cyclic process as per the critical social theory perspective. However, the researchers further define AR in a two-step process:

- *Diagnostic Stage* – this stage involves a collaborative approach between the subject and the researcher as they work together in order to evaluate a social situation.
- *Therapeutic Stage* – changes are introduced in this stage by means of change experiments.

Baskerville (1999) specifies the five stages of AR which are diagnosing, action planning, action taking, action evaluation and specifying learning. Figure 3-1 illustrates these stages:

(Adapted from Susman 1983)

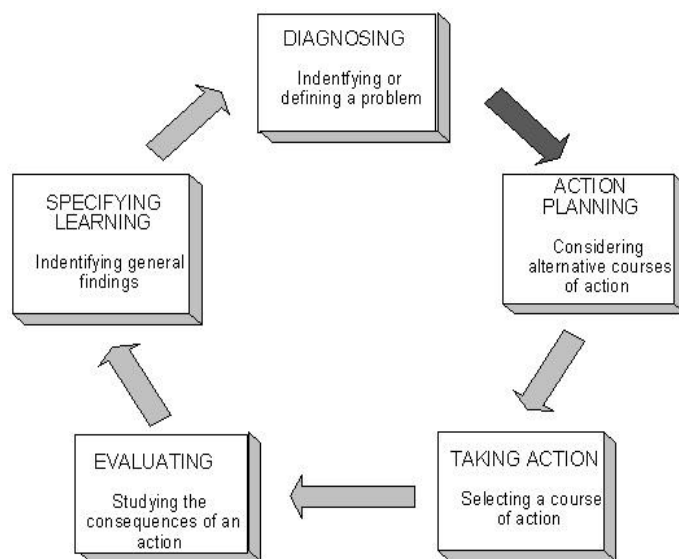


Figure 3-1: Action Research cycle

- **Diagnosing** – this stage helps identify the related and primary problems for the community or organisation.
- **Action Planning** – this stage is a collaborative effort between the researcher and participants for the purposes of addressing the identified problems from the diagnosis stage. The plan is expected to outline the preceding state of the participants or organisation.
- **Action taking** – this stage involves carrying out the planned action between the researcher and the participants in order to bring the change anticipated for the participants or organisation.
- **Evaluating** – this stage involves evaluating the action taken from the action taking phase by the researcher and participants.
- **Specifying learning** – this stage involves communicating the findings and knowledge gained to other interested parties.

3.5.3 Critical Social theory perspective of AR approach

Pretorius *et al.* (2016) state that Critical Social research delineates from a critical - dialectical perspective as its main goal is to gain a deeper understanding as per society's perspective. This study follows an AR approach with a critical social theory

perspective. In that regard, a list of guidelines is applied in line with Myers and Klein (2011). The table is listed below:

Table 3-3: Critical Social Theory Elements

(adopted from Pretorius *et al.* 2016)

ELEMENT	DESCRIPTION
Insight	This element entails in translating and understanding insight. For example, using the archaeology of knowledge and critical hermeneutics, or the social reproduction concepts through the functionalities related to symbolic capital.
Critique	This element addresses the social practices of control and reproduction, the genealogy of knowledge, and critique. This element plays a significant role in the interpretation of the research.
Transformation	This element addresses the required improvements to human existence conditions, arrangements of social existence, and social theories. These theories play both as the primary driver for change and spectrums to the researcher's world view.

To further align these elements, Myers and Klein (2011) identify principles of critical social theory in an information system perspective. There are listed in Table 3.4:

Table 3-4: Critical Social Theory (CST) principles

(adopted from Pretorius *et al.*,2016)

PRINCIPLE	SUMMARY OF MEANING
Element: Critique	
1. Core concepts principle from critical social theorists	CST researchers should use methods in line with the CST perspective such as Habermas.
2. Taking a value position Principle	Researchers should identify the important position like democracy or equality.
3. Revealing, challenging prevailing beliefs and social practices principle	CST researcher's work should be in a position to identify limitations of the research.
Element: Transformation	

4. Individual emancipation principle	Self-reflection and self-transformation should easily be realised by intervention for purposes of individual potential.
5. Improvements in society principle	Individuals may easily be transformed for the betterment of their community.
6. Improvements in social theories principle	Improvements of social theory may take place due to its own application.

The following section 3.6 outlines and discusses some of the data collection techniques that were adopted in the study.

3.6 Data Collection Techniques

A researcher can use various techniques to collect data. Some common techniques include interviews, questionnaires, observations and documents as described in Table 3-5 (Oates, 2006; Saunders *et al.*, 2009).

Table 3-5: Data collection techniques

(Adapted from Saunders *et al.*, 2009)

TECHNIQUES	DESCRIPTIONS
Interviews	• A purposeful discussion between two or more people.
Questionnaires	Include all techniques of data collection in which each person is asked to respond to the same set of questions in a predetermined order.
Observations	A systematic: • observation, • recording, • description, • analysis and interpretation of people's behaviour.

Documents	Includes written documents like: • notices, • minutes of meetings, • diaries, • administrative and public records and • reports to shareholders. Further includes non-written documents like: • voice and video recordings, • pictures, • films and television programmes.
------------------	--

Collected data may be grouped into quantitative data and qualitative data.

Saunders *et al.* (2009:151) define quantitative data as:

“A synonym for any data collection technique (such as a questionnaire) or data analysis procedure (such as graphs or statistics) that generates or uses numerical data.”

Qualitative data are defined by Saunders *et al.* (2009:151) as:

“A synonym for any data collection technique (such as an interview) or data analysis procedure (such as categorising data) that generates or uses non-numerical data.”

Seaman (1999) states that qualitative data is richer than quantitative data and data collected using qualitative methods contain more information than data collected using quantitative methods.

On occasions, data collection techniques are combined and when qualitative and quantitative data are combined it is known as a mix-method technique and is referred to as triangulation (Saunders *et al.*, 2009).

The following section 3.6.1 outlines and discusses interviews as one of the methods which was adopted in this study.

3.6.1 Interviews

An interview is a purposeful conversation between two or more people (Kahn & Cannell, 1957). Saunders *et al.* (2009) state that valid and reliable data may be collected using interviews for research purposes. Several types of interviews are available as described in Table 3-6 below:

Table 3-6: Interview types

(Adapted from Saunders *et al.*, 2009)

TYPE	DESCRIPTION
Structured interviews	• Questionnaires based on a predetermined and standardised set of questions. • An identical set of questions. • Interviewer-administered questionnaires.
Semi-structured interviews	• List of themes and questions to be covered. • May vary from interview to interview.
Unstructured interviews	• Informal. • Explore a general area in depth. • Area of interest.

Structured interviews are used for the evaluation of an artefact in the real-world application environment (RAE) while semi-structured interviews are used for problem identification and requirements gathering. Interview guidelines help to organise interviews.

3.6.2 Interview guidelines

An interview requires proper planning to establish goals and a plan to account for practical issues that may arise. For this reason, Rogers *et al.* (2011) recommend what

is called a pilot study to reveal any problems and to gain essential experience. Rogers *et al.* (2011) proposed several guidelines as summarised in Table 3-7:

Table 3-7: Guidelines for conducting interviews

(Adapted from Rogers *et al.*, 2011)

GUIDELINES	REASON
Avoid long questions.	Difficult to remember.
Compound questions should be deconstructed into separate questions.	Could be confusing.
Do not use technical terms.	Not always fully understood by the interviewee.
Leading questions should be avoided.	This presupposes a particular response from interviewees.
Biases should not be reflected in the questions posed.	Interviewers must be aware of personal biases.

Several stages for conducting an interview is suggested by Rogers *et al.* (2011). Table 3-8 summarises these stages.

Table 3-8: Stages during an interview

(Adapted from Rogers *et al.*, 2011)

STAGE	REASON
Introductory session	The interviewer: • introduces himself/herself; • explains the purpose of the interview; • reassures the interviewee; • explains how the data collected will be used; and • seeks the interviewee 's permission for the use of the data.
Warm-up session	• The interviewer asks simple, general questions, e.g. ○ Demographic questions.

Main session	• The interviewer asks questions that address the focus of the interview. • Questions are posed in ways that depend on the response of each participant.
Cooling-off period	• The interviewer asks further simple questions. ○ This eases any tension. • An opportunity is given for interviewees to provide any information they wish to add.
Closing session	• The interviewer thanks the interviewee for participating.

Professionalism is the golden rule when conducting interviews. Rogers *et al.* (2011) provides advice in this regard:

- Dress like the interviewees if possible or dress neatly and avoid standing out;
- Prepare an informed consent form for signing;
- If recordings are used, test the recording device prior to the interview and it is used properly; and
- Record answers accurately.

The qualitative data of this study is analysed using qualitative data analysis.

3.6.3 Qualitative Data Analysis

During the process of qualitative data analysis where raw data is organised into logical and meaningful units of information some creativity is necessary (Hoepfl, 1997). This process of qualitative data analysis consists of three stages: the identification stage, the re-examination stage and the translation stage.

During the *identification stage*, meaningful themes emerge from the raw data (Hoepfl, 1997). This process is referred to as 'open coding' by Strauss and Corbin (1990). In the open coding process, conceptual themes are identified and named and the observed phenomena will be grouped into these themes. The aim of identifying

themes is to create descriptive, multi-dimensional categories, which form a preliminary framework for analysis (Hoepfl, 1997).

In the *re-examination stage*, connections between the identified themes are determined by means of re-examination (Hoepfl, 1997). This complex process is developed by Strauss and Corbin (1990) and is referred to as 'axial coding'.

The *translation stage* of qualitative data analysis converts the conceptual model into a story line and should "closely approximate the reality it represents" (Strauss & Corbin, 1990:57).

Although these stages are linear, they may happen simultaneously or repeatedly. Hoepfl (1997) also states that if gaps are discovered in the data, further data collection may occur during any stage.

The next section discusses the research process of this study.

3.7 Research Process of this study

This section outlines the research process that was followed. A summary of the approach is as follows.

- **Philosophy:** The chosen philosophy for this study is mainly CST. As already described in section 3.2, the philosophical assumption has three dimensions namely ontological, epistemological and methodological. However, Vaishnavi and Kuechler (2004) identified a fourth philosophical assumption namely axiological. But in line with this research and the CST aspect, the ontological assumption is qualitative as a collaborative data gathering process was followed with educators during evaluations. The epistemological assumption of this research, however, is based on the literature review with regard to serious games and how, thus far, it has evolved from inception ever since researchers delved in experimenting with serious games in hopes of improving the learning

curve for students in their respective and different fields. Lastly, the methodological assumption of this research is in line with the AR approach as there are cyclic steps that were applied.

- **Methodology:** The methodology used was AR, which was informed by qualitative case study methodology. The AR methodology was applied through this research study and the focus was on the collaborative evaluations with the educators. A report was compiled in alignment with the AR process as well.
- **Approach:** The data was analysed through both *inductive* and *deductive* means. Data analysis was done both inductively and deductively as both document review and primary data analysis were performed to ground the data more assertively not only with documents but also with the real gathered information from participants as well.
- **Research strategy:** The strategy used in the study is the *case study approach*. Crowe *et al.*, (2011) describe a case study in research as an approach that is used to gather and process in-depth, multi-faceted data for comprehension purposes too difficult to understand for situations in a real-life setting. The researchers further categorise this case study approach in three different ways. The first type being referred to as intrinsic, the second one is called instrumental and the third one is identified as collective. Having this brief description, this study adopted observations and in-depth interviews to ground the study in relevant data.
- **Data collection techniques used:** The data collection techniques used included *primary data*, in the form of the validations from collaborative participants and *secondary data*, sought from literature reviews.

- **Data analysis:** Employed hermeneutics, descriptive statistics techniques to make meaningful examinations of the collected data as well as within cross and holistic case analysis. *Triangulation* of results was therefore applied.

3.8 Conclusion

This chapter addressed the research paradigms and research forms that are practised in the Information Systems field. There were two research forms discussed and these are qualitative and quantitative research. Following the research form discussion, research paradigms were addressed, and these are positivism, interpretivism, critical/constructionist and design science. AR was further elaborated as it is the main research approach adopted in this research.

CHAPTER FOUR: EMPIRICAL FINDINGS

4.1 Introduction

The purpose of the chapter is to report on the empirical process followed in this study. The literature was consulted, and a problem was recognised. Research noted a declining number of student enrolment in tertiary education with regard to computer science as many students perceive core modules in computer science, specifically programming, to be difficult to study; this was the reason the problem was identified. This in turn raised a need for an innovative learning approach suitable for computer science and IT students. The problem statement for this study was therefore formulated as it became imperative to find a befitting solution for this generation of tech savvy students.

The purpose of this study was to identify and use selection criteria for serious games to assist students in learning programming concepts. A literature study revealed that many students are conversant with technology, thereby making it more probable for them to experiment with technology in hopes of enhancing their learning process.

The AR methodology and the steps that were taken to implement the recommended process in this research are also described. The rest of this chapter reports on the research process that was followed to execute the research.

4.2 Research Approach

The primary objective of AR is to provide solutions by diagnosing the environment that has problems with participants through action taking (Botes & Goede, 2014). The researcher further investigates the participants' role in the social setting to make sure that opportunities for improvements are addressed and implemented with critical friends by collaborative means (Riel, 2010). The philosophical stance, as highlighted in section 3.7 of chapter three, aligns with the critical social research paradigm as the researcher investigates the underlining problem (Harvey, 1990).

AR is suitable for places such as the workplace or community space (Riel, 2010). In line with the research problem of this study, educators from a HEI in the Gauteng province of South Africa were approached. In this case, the research took place with educators in the computer science and IT field. Communication was done via email, where the nature of the study was explained, and one-on-one appointments were scheduled. The research questions and objectives of the study were explained to the participants. The research approach was also outlined to the participants. The serious game attributes, in a form of a selection criteria, was presented to the participants. Further to that, a series of serious games were later tested after evaluating the selection criteria of gaming attributes. After acquiring consent from participants, in-depth one-on-one semi-structured interviews, analysis and evaluations occurred in two AR cycles. Data collection took place till data saturation (Ness, 2015; Boddy 2016). As such, five participants contributed to the data collection and analysis process of this study.

4.3 Application of the AR Process Model

This section describes the steps that were taken to address the process for creating the selection criteria of serious games through AR.

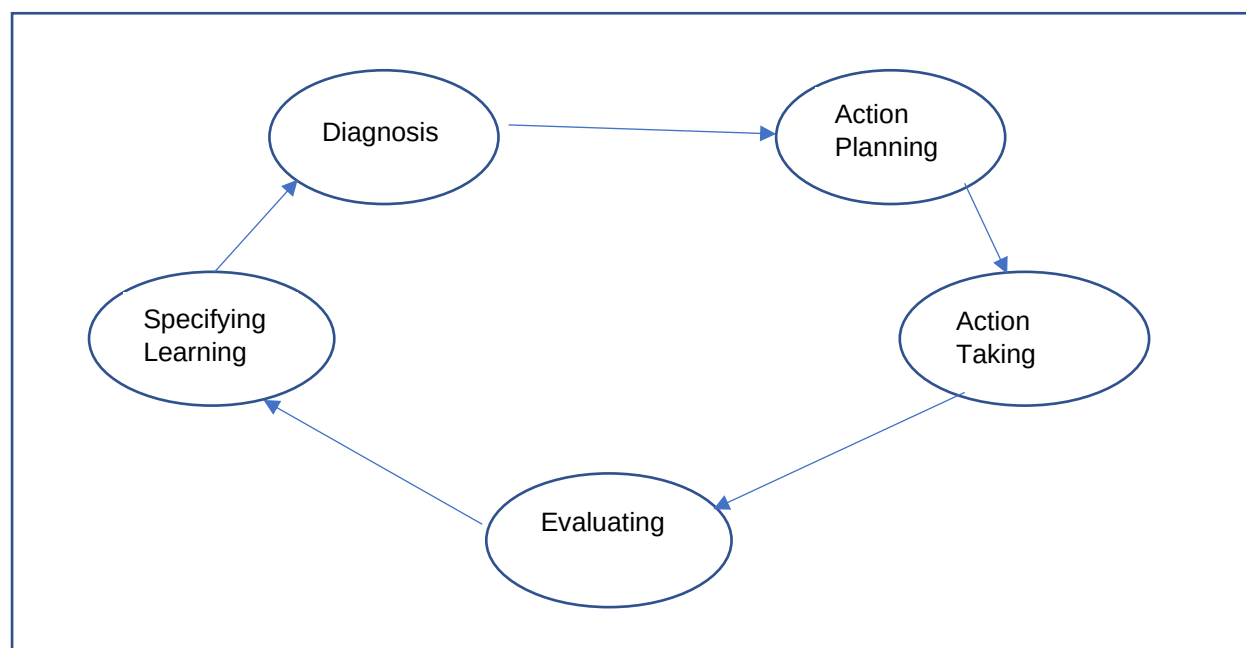


Figure 4-1: AR process model

The primary objective of AR is to provide solutions by diagnosing the environment where people experience problems and action taking to improve their situation. There were two research questions the study attempted to address. The first research question was “*Which attributes are essential in characterising serious games for selection to learn computer programming concepts?*” and the second research question was “*How can serious games attributes be applied as selection criteria to comprehensively evaluate a serious game for computer learning programming concepts?*” In that regard, two AR cycles were adopted to address these research questions. The first cycle addresses the former research question posed.

4.4 Pilot study

A Pilot Study (PS) is a process of conducting a research study with a sample data set (Kinchin *et al.*, 2018). A PS is useful as it allows the researcher to determine and address any research problems that may be encountered (Van Teijlingen & Hundley, 2001). Kinchin *et al.* (2018) affirm that a PS allows researchers to familiarise themselves with the research tools for the study and that it consequently harmonises the communication process between the researcher and participants; in the case of qualitative studies.

The research tools adopted in this PS were one-on-one semi-structured interviews and observations. A single participant was used for the PS. The participant in this PS fitted the required sample specifications of being either a lecturer or a professional in computer science and IT field from a HEI.

It was imperative to make sure that the tools and methodology used in this PS were in line with the research plan for the final data gathering process. AR was adopted as a research methodology. As such, the participant was interviewed at the beginning of this process. Audio recordings from the interview were transcribed as it was the purpose of the PS to determine if the designed interview questions were in line with the set research objectives of this study. The interview time frame was one week. This time frame allowed for an evaluation of two cycles of AR. The interview durations were

between 45-60 minutes as the participant had to evaluate the proposed serious game selection criteria against a set of mobile based serious games in programming. The participant was given a set of three mobile based serious games to test and evaluate.

The proposed designed PS elucidated some problems that resulted in reframing some of the interview questions. For instance, the reframed interview questions incorporated alternatives concerning negative responses as the interview questions were initially structured with the assumption that lecturers understood the concept of selecting and incorporating serious games in their classrooms. The PS also helped the researcher in understanding how to use the proposed research tools effectively. The one-on-one semi-structured interviews proved to be an effective tool for qualitative data gathering as they allowed for an easy and flexible approach with respect to asking and directing questions to the participants.

The data gathered further allowed for better analysis of the research. The interview proved to contain rich data, and this built a foundation for the following interviews to come in this study. The data was also used as part of the main research as the participants addressed pertinent issues that the research question of this study addressed.

The PS process allowed for the identification of various issues that were addressed in later interview sessions. The changes that took place as a result of conducting the PS are as follows:

- The serious game evaluation model was modified to include a scoring approach instead of just simply identifying the associated and existing serious game features. Initially, the model was designed to only allow the user to identify features from a serious game and then check off these features against the existing list of game features suitable for learning from the serious game model. After the pilot interview, it made sense to have a point system against these identified serious game features as this would allow for a better ranking

system when a user must compare between varieties of related serious games based on the serious game features.

- The number of serious games to be evaluated by the participants was changed from five to three. This happened as the participants needed to spend some time in testing each potential game individually. Overall, only three games were used during the course of this study.
- The post-evaluation questions or statements requiring a simple yes or no response had to be reduced from nine to eight as the first two statements generated a similar response. It therefore made sense to combine the two statements. Please refer to Appendix B for more detail and information.

4.5 Action Research: Cycle one

The following section addresses the AR cycles that took place in cycle one of this study. Figure 4-2 summarises the process followed in cycle one.

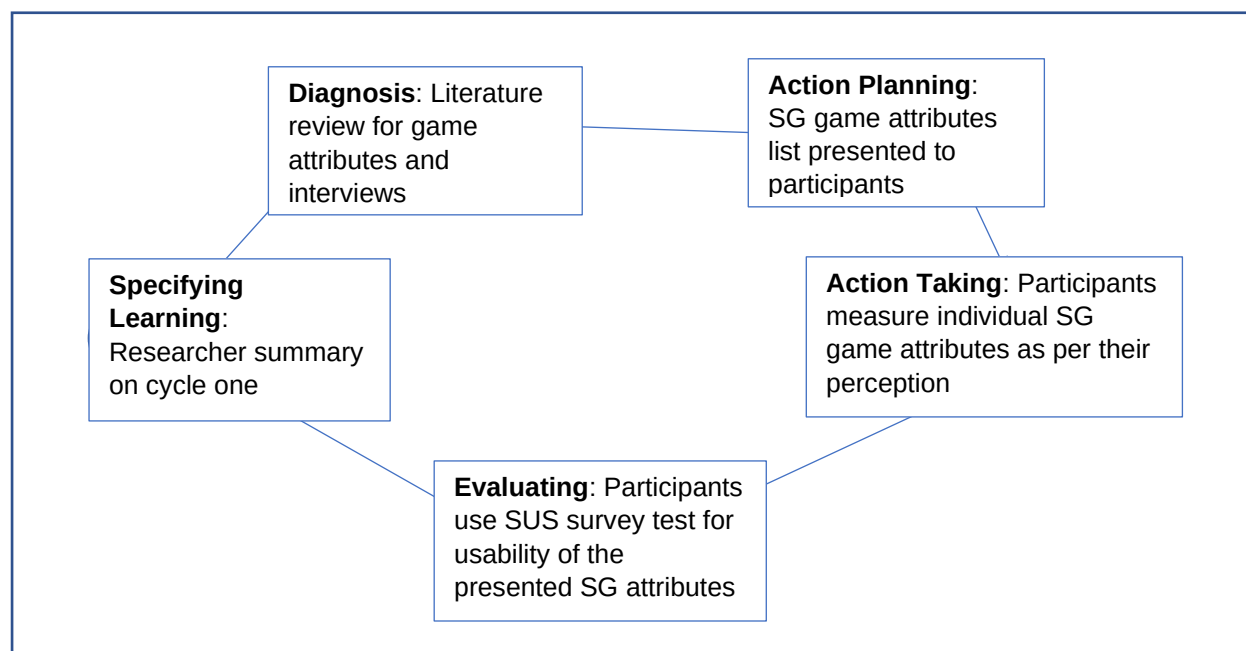


Figure 4-2: Cycle one AR summary

4.5.1 Diagnosis

Through an extensive literature review, a proposal was drafted to address the challenges that were discovered and made by other researchers in the computer science field about students learning programming and the potential solutions to such

a challenge. This then created the foundation to further embark on a similar challenge but in the context of novice programmers and first year computer science and IT students at the HEI.

In the proposal, the problem statement outlined two focal points with regard to the challenges faced by IT students. Firstly, it identified that students struggle with technical subjects, such as programming, and as such they lose interest and eventually develop a negative mind set for the subject (Khaleel *et al.*, 2015). Secondly, it also noted that serious games are a viable solution as they may reduce levels of boredom and increase interest in learning for today's learner (Pranantha *et al.*, 2012; Khaleel *et al.*, 2015; Mbogo *et al.*, 2014). Therefore, this study aimed to come up with a selection criterion for serious games to assist students in learning programming concepts.

To achieve this, interviews were conducted with educators to gather pertinent information with regard to appropriate serious game attributes that may be deemed ideal for learning computer programming concepts. A list of identified serious game attributes was identified in section 2.3.2 of chapter two and used as per the literature. The list was then provided to all participants for assessment and feedback. Each serious game attribute was listed and described in order to give a clear picture of how the participants may understand and use it.

It is well known that games have proven to be the go-to method for training as they are deemed affordable and effective (Wilson *et al.*, 2009). But in line with educational games, there is a need to make sure that the learning outcomes of the intended game are in line with that of a traditional method (Bedwell *et al.*, 2012). Therefore, several researchers and game designers have attributed to realise this relationship between learning objectives and gameplay. Bloom's taxonomy highlights these game attributes and how these game attributes aligned with learning outcomes. Heintz & Law (2012) further stipulate on the game attributes.

The list of summarised gaming attributes provided the basis for selection criteria which enabled the identification and evaluation process for existing educational games in learning fundamental programming concepts. Some of the features from Heintz and Law's (2012) game attributes table also focus on a constructivist theory such as scaffolding as such an approach is mostly favoured with regard to undergraduate studies (Battistella & von Wangenheim, 2016).

The identified attributes allowed for a framing of questions that enabled the researcher to engage with the participants. The main purpose of the first research question was to identify suitable gaming attributes that may enable the selection and evaluation of serious games in computer programming. The interviews in this first cycle focused on understanding if educators knew of any gaming attributes that they could associate with learning and playing serious games in programming concepts and secondly, if they could relate and understand the identified gaming attributes presented to them. Table 4.1 depicts a sample of interview questions that were posed to the participants in order to get insights with regard to game attributes and selecting serious games:

Table 4-1: Sample interview questions

Question	Nature of question
What are your thoughts on applying serious games to computer science education? How and to what extent?	Open ended
Do you think mobile devices can help to enhance computer science education? Why?	Open ended
On a scale of 1-5, can you rate how the following serious game attributes can be important in selecting a serious game for learning computer programming concepts.	Closed ended/scale based
How often would you use this framework of serious game attributes to select a serious game for your class, and why?	Open ended

Do you have any additional thoughts?	Open ended
--------------------------------------	------------

Participants were interviewed and their responses were gathered and analysed. These preliminary interviews allowed the researcher to understand the extent to which educators understood serious game features/attributes. Table 4.2 shows participants responses:

Table 4-2: Code and quote from participant's response

Code	Quote
Interaction component	Q: <i>Do you know of any serious game attributes/characteristics?</i> R: “What I do understand about serious games is that they have to have some kind of <u>interaction component</u> between the user in the game so the user must <u>interact</u> with the game, so they get to learn something and also is that <u>educational aspect</u> the games at the end of the day they should educate the user they should impart some knowledge on the user and it's just not only for fun so”
Education aspect	Q: <i>Do you think mobile serious games can help to enhance computer science education? Why/ please explain?</i> R: “I just know that in each and <u>every game everyone learns</u> in every game like if it's a fighting game it will teach you how to fight e.g. killing zombies.
Game attributes	Q: <i>Do you know of any serious game attributes/characteristics?</i> R: “Take for example in the fighting game which ever <u>level</u> or stage you have to <u>complete it in doing the required main task</u> like killing the boss or something or acquiring so many <u>points</u>, reaching a certain destination or completing certain task or something like that...”

Participants were able to deduce some of the serious game attributes based on their professional experience. The quotes illustrated in table 4-2 suggest three of such attributes; which are an interaction component, an educational aspect and various game attributes, like points and levels, of a serious game. However, these attributes

are well included in the selection criteria that was presented to the participants. Nonetheless, this affirmed to the researcher as it aligned with existing literature.

Table 4-3: Identified main themes from transcripts

Educational elements	Motivational game elements
Teaching of game	Player game engagement
Teaching techniques	Important gaming elements
Game Selection	Learning aspect of game playing
Serious game perception	Useful game attributes
Learners' attitude towards serious games	
Serious game design principles	

Through thematic analysis the researcher identified themes and major categories of relatable attributes that are deemed important in learning and serious games (Braun and Clarke, 2006). Please refer to appendix C for more information. As per the interview sessions conducted and illustrated in table 4-3, the researcher deduced and identified two major categories, which are educational elements and motivational game elements, and these are briefly described below.

4.5.1.1 Educational elements

Participants were asked about their perception with regard to the use of serious games in classrooms. It was noted that the teaching approach played an important role in associating serious games with the learning content for the students. Participant one expressed his opinion that games should always have an underlying learning factor:

P1: *"I just know that in each and every game everyone learns in every game"*

Participants also agreed that it is crucial to select a game relevant to the learning approach of that module:

P1: *"No, I haven't because of the module that am doing has nothing to do with serious games"*

P3: *"I don't think that No I think it's not related to the foundation rather than I'm not involved in teaching something related to programming languages"*

However, it was noted that participants as educators were not keen on using serious games as part of their teaching strategy simply because of their lack of interest:

P3: *"...not you know I'm not into games"*

P4: *"I am aware of one of the Something combat, something code combat or called stuff like that but it didn't really interest me"*

Nonetheless, it is evident that learning as a result of playing is important for any game to be a relevant tool in assisting a user when considering learning through playing games. A suggestion from participant two indicated the use of some game playing elements in order to enforce the learning process for students. Participant two indicated that students were instructed to design their own games by using platforms with game like features that use a drag and drop mechanism:

P2: *"we do help to teach students of the extended programme how to programme simple games"*

But overall, the perception and attitude behind the use of serious games themselves appeared to be the hinging factor of whether an educator might use serious games as a tool to assist students with learning.

4.5.1.2 Motivational game elements

Despite the consensus that the participants have never used serious games as a tool to assist students in learning, it was clear that the level of engagement between the player and game was important for the game to be useful. Participant two pointed out that the interaction between the game and the player was important:

P2: *"What I do understand about serious games is that they have to have some kind of interaction component between the user in the game"*

Participant one concurred that a player should be motivated to play and be engaged with a game by getting useful feedback and rewards when successfully accomplishing tasks:

P1: *"Take for example in the fighting game which ever level or stage you have to complete it in doing the required main task like killing the boss or something or acquiring so many points"*

It is also imperative to balance the playing aspect with the learning attributes in order to motivate players in a game. Participants ultimately agreed that immersing a player in a game might encourage them to play more thereby allow them to also learn more:

P1: *"in every serious game the player needs to know that they are playing something, maybe moving a character by doing a certain task but they must be that thing of playing a game"*

P2: *"yes you can have nice visuals but remember the main point of serious games is to educate"*

P4: *"when I try to think of what the students want and what will help the students, I think about what would have helped me to learn programming and that specific game"*

These responses enabled the researcher to understand what the participants' perception was with regard to serious games attributes in relation to existing literature. After analysing the responses, the identified serious game attributes were compared with those in existing literature.

4.5.2 Action Planning

The diagnosis phase enabled the researcher to identify critical areas with regard to the educators' knowledge and perspective of the serious game attributes. The first

cycle attempted to address the first research question of this study, which is “*What are the suitable attributes that make a serious game with regard to learning programming fundamentals?*” Educators were approached for an interview and feedback was gathered and analysed. A list of potential game attributes associated with serious games was presented to the educators. These attributes were then evaluated by the educators through SUS survey questions.

Table 4-4 illustrates the selection criteria of game attributes used to evaluate serious games in learning programming concepts. The initial interviews with the educators and the literature review enabled a better understanding of the serious game features that would enable learning through serious games. Participants used these selection criteria (see Table 2-2) to evaluate the potential serious games and their gaming features against those in the list.

Table 4-4: Serious game evaluation model

Category	(x)	Game Features (deemed to support learning)	Score (1 to 5) 1= poor and 5 = great
Action Language		Language/Communication: textual or visual	
Assessment		Assessment: feedback to learn from previous actions	
		Progress: players progress towards the end of the game	
Conflict/Challenge		Adaption: adjust difficulty to skill level of player	
		Challenge: progressive, well balanced difficulty + clear goals	
		Conflict: solvable problems	

		Surprise: random element of the game	
Control		Control: player's power or influence over elements in game	
		Interaction (Equipment): game responds to player's action	
Environment		Location: physical or virtual world the game takes place in	
Game Fiction		Fantasy: make-believe, i.e. take on role or simulate process	
		Mystery: sensory or cognitive curiosity to obtain information	
Human Interaction		Interaction (Interpersonal): competition, acknowledgement	
		Interaction (Social): activity shared with others	
Immersion		Pieces or Players: objects or people included in narrative	
		Representation: perception of game reality, enables focus	
		Sensory Stimuli: temporary acceptance of alternate reality	
		Safety: no consequences other than possibly losing	
Rules/Goals		Rules/Goals: criteria of how to win; need to be well-defined	

Table 4-4 is the selection criteria of game attributes that was presented to and used by participants to evaluate potential serious games with regard to learning computer programming concepts. But to affirm on the incorporated serious games attributes, participants were asked to evaluate each of the listed attributes based on their understanding and perception before using them to evaluate an actual serious game. They were asked to scale the attributes between one to five; one being strongly disagree and five being strongly agree.

4.5.3 Action Taking

Participants were presented with a list of compiled serious game attributes. They were asked to measure each of the individual serious games attributes as per their importance to determine the effectiveness of a potential serious game based on the participant's perspective as an educator.

4.5.4 Evaluating

To evaluate the identified game attributes and selection criteria, educators in the computer science and IT field were approached and interviewed. *Usability/user testing* or *System Usability Scale (SUS)* was also used as a form of evaluation approach for the study. This technique usually involves measuring users' performance on typical tasks. It is also an approach that emphasises on the property of being usable (Brooke, 1996). It mainly focuses on testing the usability of the product rather than users themselves. The main goal of a usability test is to see if the product developed is usable by the intended user population as per the developers' expectations.

4.5.4.1 Participants' cycle one Evaluation

During the evaluation process, educators in the computer science and IT field were approached and interviewed. After presenting the list of identified game attributes, a review and feedback process took place. A checklist based on standard usability test questions was drawn and analysed to see if the list of the intended gaming attributes performed as intended by the researcher. Table 4.5 is a list of the areas that were considered for the selection criteria list:

Table 4-5: SUS questions and evaluation analysis

Evaluation analysis	SUS Questions
Complexity	I found the game attributes unnecessarily complex. I found that the various attributes in the game attributes were well integrated.
Simplicity	I thought that the game attributes were easy to understand. I think that I would need assistance to be able to understand the game attributes. I would imagine that most people would understand game attributes very quickly.
Consistency	I thought that there was too much inconsistency in the game attributes. I found the game attributes very cumbersome/awkward to understand. I felt very confident understanding the game attributes.
Relevance	I needed to learn a lot of things before I could understand the game attributes.

Table 4.5 illustrates the focus areas that were assessed by the educators during the structured walk-through evaluation. After going through the feedback process, the educators made notes on a few things which were:

- *Simplicity* – the game attributes were easy to use and simple to understand.
- *Complexity* - the game attributes were not complex as the list was an easy enough concept to grasp.
- *Consistency* – the serious game attributes maintained a unified theme with regard to its concept and functionality.

- *Relevance* – the serious game attributes were relevant as these attributes aligned with the learning concept to be achieved by the learning objective of a serious game.

Table 4-6: SUS responses of Participants

SUS question	Participants' Responses				
	P1	P2	P3	P4	P5
I found the game attributes unnecessarily complex.	No	No	No	No	No
I found the various elements in the game attributes were well integrated.	Yes	Yes	Yes	Yes	Yes
I thought that the game attributes were easy to understand.	Yes	Yes	Yes	Yes	Yes
I think that I would need assistance to be able to understand the game attributes.	No	No	No	No	No
I would imagine that most people would understand the game attributes very quickly.	Yes	Yes	Yes	Yes	Yes
I thought that there was too much inconsistency in the game attributes.	No	No	No	No	No
I found the game attributes very cumbersome/awkward to understand.	No	No	No	No	No
I felt very confident understanding the game attributes.	Yes	Yes	Yes	Yes	Yes
I needed to learn a lot of things before I could understand the game attributes.	No	No	No	No	No

The participants revealed that the presented list of attributes was comprehensive and aligned with the needs of serious games. So, based on this analysis and feedback, as illustrated in table 4-6, a second cycle process took place to address the second research question of this study.

4.5.5 Specified Learning

Cycle one entailed addressing the first research question of this study. Upon data collection and analysis evaluation, a summary and reflection of the first cycle took place. At the beginning of the AR process, a problem was identified in the form of a problem statement. The problem statement stated that there is need to come up with innovative ways that can assist students with learning programming concepts, in this case, by means of using selection criteria for educators to choose a serious game. Literature review and an assessment of similar games in this field was conducted as the basis for identifying relevant serious game attributes. The researcher proposed to come up with selection criteria based on identified serious games attributes with regard to learning programming concepts.

The list presented to the participants proved helpful with regard to associating game attributes and identifying potential serious games in learning programming. As the purpose of this study was to use existing serious game attributes, the first cycle addressed the research question by adopting the Heintz and Law's (2012) framework. The participants were able to identify some of the attributes easily as they were also familiar with mainstream entertainment video games.

4.6 Action Research: cycle two

This section addresses the steps in cycle two and how the researcher approached the research through these steps. Figure 4-3 summarises the processes taken in cycle two.

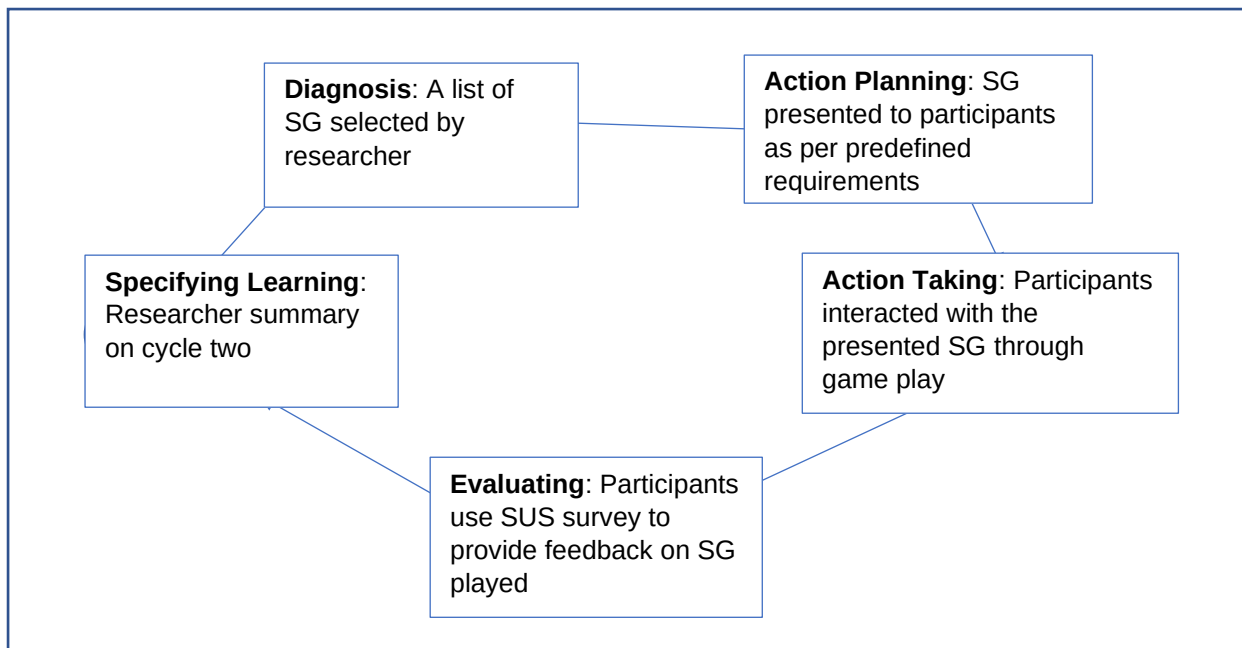


Figure 4-3: Cycle two AR summary

4.6.1 Diagnosis

During the first cycle, participants were presented with a list of serious games attributes. These attributes made up the selection criteria for serious games with regards to learning programming concepts. The researcher discovered that the participants were not familiar with serious games about learning programming concepts. Therefore, a list of specified serious games was chosen and selected by the researcher based on existing literature and requirements. The games were presented to the participants for evaluation based on selection criteria game attributes.

4.6.2 Action Planning

Using the identified serious game attributes list, a study was designed to gather information from the participants to determine which of the presented serious games in programming appeared to be most effective through the use and identification of the attributes from the derived list in cycle one. Each participant was approached with a list of three serious games. Thereafter, they were asked to evaluate the game with respect to each of the identified attributes, using a user testing approach in a semi-structured interview format. Finally, the participants were asked to rate the game by describing its effectiveness with regard to learning computer programming concepts.

Three serious games were selected for the participants to evaluate. Google play store was used to select these serious games. The serious games had to be in line with a particular criterion to be used for this study. The serious games had:

- To address the primary concern of learning programming through game play
- To be mobile based
- To run on an android platform
- To be free for download and play

Any game fulfilling these requirements was then considered to be used in this study. In this case, the three games, namely Light-bot, RoboZZle Droid and Algorithm city were chosen for this study and are described below.

4.6.2.1 Light – Bot

Light-bot is a serious game that has been designed to help players learn programming through fun and engaging game play. The primary objective of this game is to command a robot through various mazes with purposes of turning a light on at the end of the maze. A player achieves this by instructing the robot using a series of arrows. This game allows the player to grab basic computer programming concepts abstractly. For instance, the player can input a series of instructions thereby a basic algorithm. Below is an image illustrating light-bot:

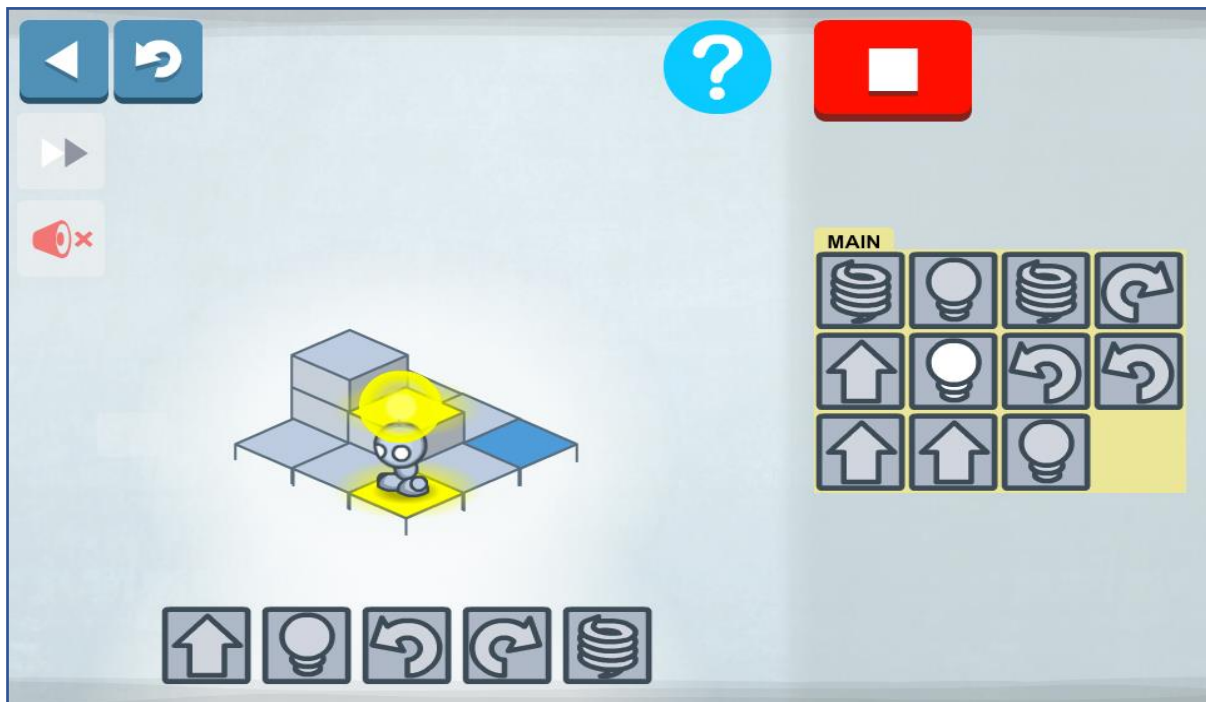


Figure 4-4: Light – bot

4.6.2.2 RoboZZle Droid

RoboZZle Droid is a game designed to use programming logic in order to play. A player instructs a robot through a series of mazes using arrows. The player must apply the same basic computer programming logic and concepts to accomplish the primary objective of beating the maze. Below is an image illustrating RoboZZle Droid:



Figure 4-5: RoboZZle Droid

4.6.2.3 Algorithm City

Algorithm City is a game designed to teach new learners in computer programming. It adopts different types of animals that a player can choose from and then use a combination of arrows for instructions. The player is supposed to apply various computer programming concepts to move the game object through a series of mazes to collect coins. Below is an image of algorithm city:



Figure 4-6: Algorithm City

4.6.3 Action taking

After addressing the first research question in cycle one, cycle two attempted to address the second research question. The second research question of the study is *“How can serious game attributes be applied, in selection criteria, to comprehensively evaluate a serious game for computer learning programming concepts?”* In order to address this question, three serious games in programming were presented to educators in the computer science and IT field. These games were selected from a list of compiled mobile serious games in computer programming. Please see appendix A for the list of games related to learning programming concepts. The participants were asked to play a series of games and evaluate them as per the identified and presented serious game attributes from the first cycle. They were to use these identified gaming attributes to determine the effectiveness of their preferred chosen game.

4.6.4 Evaluating

4.6.4.1 Participants' cycle two Evaluation

The educators in the computer science and IT field were approached for evaluation. The participants gave their personal perspective on the selection process of serious games with regard to learning programming.

A feedback session was conducted with the individual participants after which data was gathered. The responses analysed were in line with the participants' responses. Table 4-7 highlights the analysed results:

Table 4-7: Evaluation Analysis and SUS Questions

Evaluation analysis	SUS Questions
Usefulness	I found the game selection criteria model easy to use. I think that I would need assistance to be able to use the selection criteria model.
Simplicity	I would imagine that most people would learn how to use the selection criteria very quickly. I thought that there was too much inconsistency in the selection criteria model. I found the selection criteria model very cumbersome/awkward to use.
Relevance	I felt very confident using the selection criteria model. I needed to learn a lot of things before I could use the selection criteria model

- *I found the game selection process unnecessarily complex* – Participants concurred that the serious game selection process was not complex as the serious game selection model was clear in the description of the game attributes deemed useful in learning. Participants also agreed that the game selection model was easy to use as it had clearly outlined objectives as per the game attribute of potential serious games.

P3: “Yes, absolutely and even if it's not with related students and undergraduates, you can start even from grade one with different levels with different type of games start learning”.

P4: “I never thought of anything like that in order to evaluate educational games, but I think it is useful”.

P5: “If I were teaching junior high students maybe I would use but in my occupation I wouldn't because I teach at a higher level”.

- *I think that I would need assistance to be able to use the selection criteria model* – The participants indicated that they would not need assistance during a selection of a game as they understood the process of figuring out and learning how the game attributes worked.
- *I would imagine that most people would learn to use the selection criteria model very quickly* – Participants agreed that fellow educators would easily learn how to use the criteria selection model as it was easy to follow and understand.
- *I thought there was too much inconsistency in the selection criteria model* – Participants noted there were no inconsistency from the selection criteria model.
- *I found the selection criteria model was very cumbersome/awkward to use* – Participants agreed that they did not find the model cumbersome or awkward as it contained descriptions on each attribute.
- *I felt very confident using the selection criteria model* – The participants agreed that they were confident during their interaction with the model. This was because the model provided a clear attribute definition.

P3: “It's around 80% that I will be using that model if I get the final feedback so after you know processing all the data and the information it's something like the feedback”.

- I needed to learn a lot of things before I could use the selection criteria model
 - Participants pointed out that they would not need to learn a lot of things before they could use the selection criteria model as the selection process is quite straight forward.

Table 4-8: SUS responses of participants

SUS question	Participants' Responses				
	P1	P2	P3	P4	P5
I found the game selection criteria model was easy to use.	Yes	Yes	Yes	Yes	Yes
I think that I would need assistance to be able to use the selection criteria model.	No	No	No	No	No
I would imagine that most people would learn to use the selection criteria model very quickly.	Yes	Yes	Yes	Yes	Yes
I thought that there was too much inconsistency in the selection criteria model.	No	No	No	No	No
I found the selection criteria model very cumbersome/awkward to understand.	No	No	No	No	No
I felt very confident using the selection criteria model.	Yes	Yes	Yes	Yes	Yes
I needed to learn a lot of things before I could use the selection criteria model.	No	No	No	No	No

Table 4-8 summarises the responses made by the educators after going through the selection process of serious games using the presented serious game attributes. It demonstrates that the participants were able to evaluate different serious games that

were similar in nature. Further to that, it indicates that the participants preferred algorithm city and light-bot compared to RoboZZle Droid.

Table 4-9: Serious games and game attributes

Game Features	Algorithm City	Light-bot	RoboZZle Droid
Language/communication	24	19	9
Assessment	23	19	10
Progress	24	19	10
Adoption	21	20	9
Challenge	17	17	7
Conflict	24	19	9
Surprise	13	20	7
Control	21	17	8
Interaction (Equipment)	22	21	14
Location	16	15	9
Fantasy	16	13	8
Mystery	18	16	10
Interaction (Interpersonal)	21	12	11
Interaction (Social)	10	7	5
Pieces/Players	19	16	9
Representation	17	17	9
Sensory	17	14	7
Safety	24	21	15
Rules/Goals	19	24	13
Aggregate Score	366	326	179

Table 4-9 highlights the selection criteria list of gaming attributes as per the serious games and their respective scores. The table shows the aggregate scores of the individual serious games as per the game attributes that they associated with. As already stipulated, the preferred serious game based on the educators' perspective is Algorithm city. This shows that this option is favoured among the participants as the aggregate score based on assessing the game attributes is higher, compared to Light-bot and RoboZZle Droid's aggregate scores.

4.6.5 Specified Learning

After conducting the two AR cycles, it became apparent that this innovative way of choosing and identifying potential serious games was important. But since the aim of this study was to identify gaming attributes suitable for selecting a serious game, AR was able to accomplish this by gaining knowledge through literature and pertinent feedback from educators that would help the teaching and learning methods in the field of computer science.

Secondly, the selection criteria list, as illustrated in table 4-4, enabled a ranking process for the most effective serious games as perceived by the educators. This allowed for a deeper understanding of assisting both educators and learners in addressing the needs to deliver and receive learning content in an innovative and relevant manner for computer programming.

4.7 Conclusion

This chapter addressed the AR process and the steps that were taken to identify serious games attributes that could be used for a selection criterion. The AR approach has been illustrated in two cycles. These cycles are also in line with the research questions of this study. A series of serious games were evaluated, and an overall view of the project was summarised.

CHAPTER FIVE: CONCLUSIONS, REFLECTIONS AND RECOMMENDATIONS

5.1 Introduction

The aim of the study was to come up with the selection criteria for serious games in learning computer programming concepts. The study further used serious games attributes from the literature for selection criteria as per the user's perspective. Several studies evaluate serious game designs for their incorporated attributes and how effective these attributes are (Steiner *et al.*, 2015; Abdellatif *et al.*, 2018). However, this study attempted to use these incorporated attributes in serious games in order to find a suitable method for selecting one from a user's perspective. In this chapter, all the identified and defined objectives are looked at and summarised, based on how each of these set objectives were achieved. Further to that, this chapter also highlights the challenges faced during the course of this research and the possible recommendations for future studies.

A set of primary, theoretical and empirical objectives were identified and defined. As stated, the primary objectives of this research were to identify and use selection criteria for serious games to assist students in learning programming concepts. However, to achieve this primary objective, secondary objectives were formulated in the form of empirical and theoretical objectives. Further to that, a thorough literature review on relevant documentation was conducted and from this, the serious game selection criteria based on game attributes was identified. Semi-structured interviews were conducted with a course convener for computer science.

Lastly, the study also discussed the empirical objectives that were derived. These objectives were to evaluate the suitability of identified serious games to assist students in learning fundamental programming concepts against the game attributes identified during the literature study and identify and use selection criteria to identify serious games to assist students in learning computer programming concepts.

5.2 Research Conclusions

This section addresses the overall processes of the defined AR cycles from chapter four.

5.2.1 Cycle one

This cycle addressed the first research questions of this study. The research question posed was “*Which attributes are essential in characterising serious games for selection to learn computer programming concepts?*” To address this, a series of theoretical and empirical objectives were formulated. In this case, an associated theoretical objective of this research question was to review the literature and identify game attributes that are associated with a good serious game. Chapter two sections 2.3.1 and 2.3.2 addressed some of the important characteristics that are important for a serious game. But in the same line, section 2.3.2 also highlighted Heintz and Law’s (2018) gaming attributes that allowed for compiling of the selection criteria for serious games in learning programming concepts. To further address this research question, an empirical objective was also formulated. The empirical objective was to identify and use selection criteria to identify serious games to assist students in learning computer programming concepts. Participants were approached and information and feedback were gathered. A detailed analysis has been discussed in chapter four after conducting a series of interviews with the participants, who were all educators in the computer science and IT field. Criteria based on the game attributes were compiled with regard to the attributes that were appropriate and associated with serious games in learning programming.

5.2.2 Cycle two

Cycle two addressed the second research question which was “*How can serious games attributes be applied as selection criteria to comprehensively evaluate a serious game for computer learning programming concepts?*” To further address this, an empirical objective was derived which was to evaluate the suitability of identified serious games to assist students in learning fundamental programming concepts against the game attributes identified during the literature study. Therefore, a series of potential serious games were presented to the participants. The participants were asked to measure a series of serious games for their effectiveness as per the

presented game attributes. The analysis has been discussed in chapter four through sections 4.4 and 4.5. The serious games were then ranked as per the participant's perspective and the selection criteria model with regard to game attributes associated with learning computer programming concepts.

5.3 Research Findings

This section addresses the findings from the two AR cycles highlighted in chapter four.

5.3.1 Cycle one findings

This cycle helped to determine the participants' perspective of serious game attributes in learning computer programming concepts. Table 5-1 summarises the perception of where game attributes would be effective in a serious game and how easily these attributes would be identifiable by the participants. From the list presented to the participants, it is evident that surprise, fantasy, interaction (social), pieces of players and safety were not highly considered for their characteristics with regard to selecting a serious game.

Table 5-1: Participants' perception of game attributes

Game Features	Participants' perspective
Language	Strongly agree
Assessment	
Progress	
Adaption	
Conflicts	
Control	
Interaction (Equipment)	
Interaction (Interpersonal)	
Representation: perception of game reality	
Rules	
Location	
Mystery	

Sensory Stimuli	Agree
Fantasy	Least Agree
Interaction (Social)	
Pieces Players	
safety	
Surprise	

5.3.2 Cycle two Findings

The analysis as per chapter four findings demonstrated that serious games attributes can be used as an essential evaluation tool for selecting an effective serious game. However, it may not be that easy to identify every particular attribute incorporated in a serious game as it still requires some insight into the design process. In addition, it was noted that the majority of the participants were not well conversant with the concept of serious games and their respective attributes. Overall, the participants preferred Algorithm city for their serious game of choice after evaluating three serious games based on their respective gaming attributes.

Table 5-2: Participants' game scoring

Name of Game	Participants game scoring					
	P1	P2	P3	P4	P5	Total
Light-Bot	68	85	58	70	45	326
RoboZZle Droid	23	43	36	39	38	179
Algorithm City	84	83	58	77	64	366

Table 5-2 summarises the participants' evaluation of the presented serious games as per the evaluation approach based on their perspective game attributes. As illustrated, the participants used the selection criteria list of serious game attributes to rank the serious games. Light-bot and Algorithm City appeared to resonate with the participants with regard to serious games that could help learners in computer programming. But

overall, Algorithm City appeared to be favoured among the participants as it scored the highest with regard to its gaming attributes and evaluation.

5.4 Challenges and Recommendations

This section addresses the challenges encountered during this research and some of the relevant recommendations that should be considered for future studies in this area of research.

5.4.1 Research Challenges

The research involved the use of mobile technology and how such technology could assist students in learning programming concepts. As such there were certain limitations with the use of such technology. One such challenge is on the hardware limitations of smartphones. As the purpose of the study was to incorporate technology that is prevalent with students, only android based smart phones were considered for this study.

Another challenge encountered during the course of this research was that the sample size of the participants of this study was limited. The evaluation process only incorporated educators with a computer science or IT background from a HEI and as such, this may have limited the degree of feedback gathered from the evaluation process.

Further to that, the list of serious games provided in this study was not exhaustive. Only a few serious games with regard to learning programming were evaluated to solidify a proof of concept.

One other challenge encountered was the lack of both sufficient time and student inclusion in the data gathering process. It would have been essential that the study incorporate not just the educators' perspective but the students' as well. Time was

also another limiting factor as the need to gather detailed feedback is essential to such qualitative studies.

5.4.2 Future study recommendations

For future studies, there are certain areas that such research may be required to follow. One such recommendation is on the inclusion of multiple devices from various platforms that cater to different player needs. The research only focused on and targeted android-based platform users. As such, it would be beneficial to also include iOS platforms, for instance. It would also be beneficial to extensively include other mobile platforms such as tablets and laptops as this may increase the reach for all types of potential future players.

Additionally, for future studies the sample size should also be considered beyond one particular department of a HEI. It would be highly beneficial for future researchers to include a wider demographic of the sample size to have extensive feedback, thereby resulting in a richer and detailed analysis and evaluation.

As stated, the list of serious games with regard to computer programming was not exhausted during the course of this study. As such, it would be beneficial to incorporate a myriad of serious games in the field of computer science for future studies.

5.5 Conclusion

This chapter addressed the primary, theoretical and empirical objective of the study and how these objectives were achieved throughout the course of this research. It also addressed some of the challenges that were encountered during the course of this study and the recommendations necessary to address these challenges for any related future studies.

REFERENCES

- Abdellatif, A.J., McCollum, B. and McMullan, P., 2018, March. Serious games: Quality characteristics evaluation framework and case study. *Integrated STEM Education Conference*. pp. 112-119.
- Adebesin, F., Kotzé, P. and Gelderblom, H., 2011. Design research as a framework to evaluate the usability and accessibility of the digital doorway. https://researchspace.csir.co.za/dspace/bitstream/handle/10204/5424/Adebesin_2011.pdf?sequence=1. Date of access: 15 Jun. 2018.
- Ahmed, J. and Shaikh, Z.A., 2011, July. Privacy issues in social networking platforms: comparative study of facebook developers platform and opensocial. *Computer Networks and Information Technology*. pp. 179-183.
- Anon, 2005. Basic Programming concepts. <http://livecode.byu.edu/programmingconcepts/ControlStruct.php>. Date of access: 22 Feb. 2018.
- Anon, 2014. Computer programming concepts. <http://www.landofcode.com/programming-intro/computer-programming-concepts.php>. Date of access: 22 Feb. 2018
- Anon., n.d. Defold. <https://www.defold.com/>. Date of access: 22 Jun. 2018.
- Anon., n.d. Facebook for developers. <https://developers.facebook.com/docs/games/instant-games/compatible-engines/>. Date of access: 21 Jun. 2018.
- Anon., n.d. Unreal Engine. <https://www.unrealengine.com/en-US/what-is-unreal-engine-4>. Date of access: 22 Jun. 2018.
- Anon., n.d. What is COCOS2D-X?. <http://www.cocos2d-x.org/>. Date of access: 22 Jun. 2018.
- Apiola, M. & Tedre, M. 2012. New perspectives on the pedagogy of programming in a developing country context. *Computer Science Education*, 22 (3):285-313.
- Backlund, P., Engström, H., Johannesson, M. & Lebram, M. 2008. Games for traffic education: An experimental study of a game-based driving simulator. *Simulation & Gaming*.
- Baskerville, R. & Wood-harper, A.T. 1998. Diversity in information systems action research methods. *European Journal of Information Systems*, 7:90-107.
- Baskerville, R.L. 1999. Investigating information systems with action research. *Communication of the association for information systems*, 2(19):2-31.
- Baskerville, R. 2008. What design science is not. *European Journal of Information Systems*, 17(5):441-443.
- Bartel, A. & Hagel, G. 2014. Engaging students with a mobile game-based learning system in university education. *Global Engineering Education Conference*. pp. 957-960.
- Battistella, P. and von Wangenheim, C.G., 2016. Games for teaching computing in higher education—a systematic review. *Technology and Engineering Education*, 9(1):8-30.

- Bedwell, W.L., Pavlas, D., Heyne, K., Lazzara, E.H. and Salas, E., 2012. Toward a taxonomy linking game attributes to learning: An empirical study. *Simulation & Gaming*, 43(6):729-760.
- Bellotti, F., Berta, R., Gloria, A.D. & Primavera, L. 2009. Enhancing the educational value of video games. *Computers in Entertainment*, 7(2):23.
- Bidarra, J., Figueiredo, M. & Natálio, C. 2015. Interactive design and gamification of eBooks for mobile and contextual learning. *International Journal of Interactive Mobile Technologies*, 9(3):24-32.
- Blake, E. 2010. Software engineering in developing communities. *Cooperative and Human Aspects of Software Engineering*. pp. 1-4.
- Blanche, M.J.T., Blanche, M.T., Durrheim, K. & Painter, D. 2006. Research in Practice: Applied Methods for the Social Sciences. 3rd ed. Cape Town: University of Cape Town Press.
- Boddy, C.R., 2016. Sample size for qualitative research. *Qualitative Market Research: An International Journal*, 19(4):426-432.
- Bodnar, C.A. and Clark, R.M., 2017. Can Game-Based Learning Enhance Engineering Communication Skills?. *Transactions on Professional Communication*, 60(1):24-41.
- Bogdanov, E., Salzmann, C. and Gillet, D., 2011. Contextual spaces with functional skins as opensocial extension. *Advances in computer-human interactions*.
- Boyinbode, O. and Ng'ambi, D., 2013. An Interactive Mobile Lecturing Tool for Empowering Distance Learners. *International Journal of Interactive Mobile Technologies*, 7(4).
- Brooke, J., 1996. SUS-A quick and dirty usability scale. *Usability evaluation in industry*, 189(194), pp.4-7.
- Bressler, D.M. and Bodzin, A.M., 2013. A mixed methods assessment of students' flow experiences during a mobile augmented reality science game. *Journal of Computer Assisted Learning*, 29(6):505-517.
- Braun, V. and Clarke, V., 2006. Using thematic analysis in psychology. *Qualitative research in psychology*, 3(2), pp.77-101.
- Bryant, A. 2002. Grounding systems research: Re-establishing grounded theory. *System Sciences, Big Island, HI*.pp. 3446-3455.
- Brydon-Miller, M. 2001. Education, research and action: Theory and methods of participatory action research. In D. L. Tolman & M. Brydon-Miller (Eds.) *From subjects to subjectivities: A handbook of interpretive and participatory methods*. New York: New York University Press. pp. 76-89
- Bulander, R., 2010, July. A conceptual framework of serious games for higher education: Conceptual framework of the game INNOV8 to train students in business process modelling. *e-Business. Athen, Greece*. pp. 1-6.
- Callaghan, M., Savin, M., MC Shane, N. and Eguiluz, A., 2015. Mapping learning and game mechanics for serious games analysis in engineering education. *Transactions on Emerging Topics in Computing*. 5(1) :77-83.

- Chan, T.W., Roschelle, J., Hsi, S., Kinshuk, Sharples, M., Brown, T., Patton, C., Cherniavsky, J., Pea, R., Norris, C. and Soloway, E., 2006. One-to-one technology-enhanced learning: An opportunity for global research collaboration. *Research and Practice in Technology Enhanced Learning*, 1(01):3-29.
- Charsky, D. 2010. From edutainment to serious games: A change in the use of game characteristics. *Games and culture*, 5(2):177-198.
- Checkland, P. and Holwell, S. 1998. Information, systems, and information systems: making sense of the field. Chichester: Wiley.
- Chigona, W., Beukes, D., Vally, J. and Tanner, M., 2009. Can mobile internet help alleviate social exclusion in developing countries?. *The Electronic Journal of Information Systems in Developing Countries*, 36.
- Chin, S., 2014. Mobile technology and Gamification: The future is now!. *Digital Information and Communication Technology and it's Applications*. Bangkok. pp. 138-143.
- Ching C, Learn Programming-Core programming concepts tutorials, 2017. <https://codewithchris.com/learn-programming/#objects>. Date of access: 22 Feb. 2018.
- Coelho, A., Kato, E., Xavier, J. and Gonçalves, R., 2011. Serious game for introductory programming. *Serious Games Development and Applications*. Springer, Berlin, Heidelberg. pp. 61-71.
- Conneely, C., Girvan, C. & Tangney, B. 2012. *An exploration into the Adaptation of the BRIDGE21 model for 21st century learning in Irish classrooms: Case Study Report for the NCCA*. Dublin: NCCA.
- Corbin, J. and Strauss, A., 1990. Grounded theory research: Procedures, canons and evaluative criteria. *Zeitschrift für Soziologie*, 19(6), pp.418-427.
- Crowe, S., Cresswell, K., Robertson, A., Huby, G., Avery, A. and Sheikh, A., 2011. The case study approach. *BMC medical research methodology*, 11(1), p.100.
- Cunningham, M. 2015. Factors impacting on adoption of Technology-enhanced Learning techniques by universities in Nairobi, Kenya. *Technology and Society*. Dublin. pp. 1-.7
- De Freitas, S. and Oliver, M., 2006. How can exploratory learning with games and simulations within the curriculum be most effectively evaluated?. *Computers & education*, 46(3):249-264.
- De Jans, S., Van Geit, K., Cauberghe, V., Hudders, L. and De Veirman, M., 2017. Using games to raise awareness: How to co-design serious mini-games?. *Computers & Education*, 110:77-87.
- De Villiers, M. 2005. Three approaches as pillars for interpretive information systems research: development research, action research and grounded theory. *South African institute of computer scientists and information technologists on IT research in developing countries*, p. 142-151.
- De Villiers, P.T. & Blignaut, A.S. 2016. Design evaluation of a forklift serious game. *International Journal of Social Sciences and Humanity Studies*, 8(2), pp.1-17.
- Davey R, 2017. Phaser – HTML5 Game Framework. <https://github.com/photonstorm/phaser>. Date of access: 21 Jun. 2018.

- Djaouti, D., Alvarez, J. & Jessel, J.-P. 2011. Classifying serious games: the G/P/S model. *Handbook of research on improving learning and motivation through educational games: Multidisciplinary approaches*, Pensilvania, EUA: IGI Global pp:118-136.
- Ebner, M. and Holzinger, A., 2007. Successful implementation of user-centered game based learning in higher education: An example from civil engineering. *Computers & education*, 49(3):873-890.
- Facer, K., Joiner, R., Stanton, D., Reid, J., Hull, R. and Kirk, D., 2004. Savannah: mobile gaming and learning?. *Journal of Computer assisted learning*, 20(6):399-409
- Fesakis, G. & Serafeim, K. 2009. Influence of the familiarization with scratch on future teachers' opinions and attitudes about programming and ICT in education. *SIGCSE BULLETIN*, 41 (3):258-262.
- Fitchat, L. & Jordaan, D. 2016. Ten heuristics to evaluate the user experience of serious games. *International Journal of Social Sciences and Humanity Studies*, 8(2), pp.209-225.
- Göbel, S., 2016. Serious games application examples. *Serious games*. Springer, Cham. pp. 319-405.
- Goede, R & De Villiers, C. 2003. Can grounded theory be used to determine whether IS practices reflect systems thinking methodologies? *Centre of Philosophy, Technology and Social Systems*, Maarssen, Holland.
- Gomes, A.J. & Mendes, A.J. 2010. A study on student performance in first year CS courses. *Innovation and technology in computer science education*, p:113-117.
- Gray, D.E. 2004. Theoretical perspectives and research methodologies. *Gray, DE Doing*.
- Gray, D.E., 2013. Theoretical perspectives and research methodology. *Doing research in the real world*. 3rd ed. LA: sage, pp.14-38.
- Greitzer, F.L., Kuchar, O.A. and Huston, K., 2007. Cognitive science implications for enhancing training effectiveness in a serious gaming context. *Educational Resources in Computing*, 7(3), p.2.
- Guba, E.G. and Lincoln, Y.S., 1994. Competing paradigms in qualitative research. *Handbook of qualitative research*, 2(163-194), p.105.
- Haddad, W. and Jurich, S., 2002. ICT for education: Potential and potency. *Technologies for education: Potential, parameters and prospects*. UNESCO and Academy for Educational Development, p.28-40.
- Häsel, M., 2011. Opensocial: an enabler for social applications on the web. *Communications of the ACM*, 54(1): 139-144.
- Harvey, L. 1990. Critical social research. London, UK: Unwin Hyman.
- Heersink, D. & Moskal, B.M. 2010. Measuring high school students' attitudes toward computing. *Computer science education*. p.446-450.
- Heintz, S. & Law, E.L.-C. 2012. Evaluating design elements for digital educational games on programming. *Human computer interaction*, 26. p.245-250

- Heintz, S. and Law, E.L.C., 2018. Digital educational games: methodologies for evaluating the impact of game type. *ACM Transactions on Computer-Human Interaction*, 25(2), p.8.
- Hennessy, S., Onguko, B., Harrison, D., Ang'ondi, E.K., Namalefe, S., Naseem, A. and Wamakote, L., 2010. Developing the use of information and communication technology to enhance teaching and learning in East African schools: Review of the literature. *Centre for Commonwealth Education & Aga Khan University Institute for Educational Development–Eastern Africa Research Report*, (1).
- Hevner, A.R., March, S.T., Park, J. and Ram, S., 2004. Design science in information systems research. *Management Information Systems Quarterly*, 28(1), p.6.
- Hoepfl, M.C., 1997. Choosing qualitative research: A primer for technology education researchers. *Journal of technology education*, 9(1):47-63.
- Hsu, W.C. and Lin, H.C.K., 2016, September. Impact of Applying WebGL Technology to Develop a Web Digital Game-Based Learning System for Computer Programming Course in Flipped Classroom. *Educational Innovation through Technology, Tianan*. pp. 64-69.
- Ibrahim, R., Yusoff, R.C.M., Mohamed-Omar, H. and Jaafar, A., 2011. Students perceptions of using educational games to learn introductory programming. *Computer and Information Science*, 4(1), p.205.
- Jackson, J. & Moore, L. 2012. Engaging students in research: benefits, lessons learned and recommendations. *50th Annual Southeast Regional Conference*. p. 339-340.
- Janarthanan, V., 2012. Serious video games: Games for education and health. *Information Technology: New Generations*. Las Vegas, NV.pp. 875-878.
- Jimoyiannis, A. and Komis, V., 2007. Examining teachers' beliefs about ICT in education: Implications of a teacher preparation programme. *Teacher development*, 11(2):149-173.
- Jordine, T., Liang, Y. and Ihler, E., 2015. A Mobile Device Based Serious Gaming Approach for Teaching and Learning Java Programming. *International Journal of Interactive Mobile Technologies*, 9(1).
- Kahn, R.L. and Cannell, C.F., 1957. The dynamics of interviewing; theory, technique, and cases.
- Kaiser, C.M. & Wisniewski, M.A. 2012. Enhancing student learning and engagement using student response systems. *Social Studies Research and Practice*, 7(2):137-149.
- Khaleel, F.L., Ashaari, N.S., Meriam, T.S., Wook, T. & Ismail, A. 2015. The study of gamification application architecture for programming language course. *9th International Conference on Ubiquitous Information Management and Communication*. p.1-5.
- Khan, C., & Chovanec, D. M. 2010. Is participatory action research relevant in the Canadian workplace? *Journal of Contemporary Issues in Education*, 5, p.34-44.

- Kinchin, G., Ismail, N. and Edwards, J.A., 2018. Pilot study, Does it really matter? Learning lessons from conducting a pilot study for a qualitative PhD thesis. *International Journal of Social Science Research*, 6(1).
- Kinash, S., 2006. Paradigms, methodology & methods. *Bond University: Australia*, 5, p.2011.
- Kirlidog, M., Van der Vyver, C. & Zeeman, M. 2011. Unfulfilled need: reasons for insufficient ICT skills in South Africa. *Information Development*, 34(1), pp.5-19.
- Klein, H.K. & Myers, M.D. 1999. A set of principles for conducting and evaluating interpretive field studies in information systems. *MIS quarterly*:67-93.
- Kotovskiy, K. 2003. Problem solving—large/small, hard/easy, conscious/nonconscious, problem-space/problem-solver. *The psychology of problem solving*, p.373.
- Krassman, A.L., Paschoal, L.N., Falcade, A. and Medina, R.D., 2015, November. Evaluation of Game-Based Learning Approaches through Digital Serious Games in Computer Science Higher Education: A Systematic Mapping. *Computer Games and Digital Entertainment*, Piaui. pp. 43-51.
- Kurkovsky, S. 2013. Mobile game development: Improving student engagement and motivation in introductory computing courses. *Computer Science Education*, 23 (2):138-157.
- Lameras, P., 2015. Essential features of serious games design in higher education. *Learning*, 4(5).
- Lemke, J.L., 1999. Discourse and organizational dynamics: Website communication and institutional change. *Discourse & Society*, 10(1):21-47.
- Livingstone, S., 2012. Critical reflections on the benefits of ICT in education. *Oxford review of education*, 38(1):9-24.
- Maheshwari V.K. 2012. Action Research In Education. <http://www.vkmaheshwari.com/WP>. Date of access: 7th Mar. 2019.
- Maleko, M., 2014. *The mobile social learning environment for novice programmers*. RMIT. <http://researchbank.rmit.edu.au/view/rmit:161169>. Date of access: 8th Sep. 2017.
- Malliarakis, C., Satratzemi, M. and Xinogalos, S., 2014. Educational games for teaching computer programming. *Research on e-Learning and ICT in Education*, Springer, New York, NY. pp. 87-98.
- Marczyk, G.R., DeMatteo, D. & Festinger, D. 2005. Essentials of Research Design and Methodology. 1st ed. Hoboken: Wiley.
- Marquez-Tellez, A., Vazquez-Briseno, M., Nieto-Hipolito, J.I. and LOPEZ, J.S., 2017. Using sensor fusion in a serious game for children nutrition education. *Electronics, Communications and Computers*, Cholula. pp. 1-6.
- Marshall, B. and Chris, P. 2000. Basics of C Programming. <https://computer.howstuffworks.com/c.htm>. Date of access: 20 Apr. 2018.
- Mavridis, A., Leftheris, I., Tsiatsos, T. and Kudryavtseva, N., 2012. Supporting virtual internationalization of education by implementing and playing serious games. *Interactive Collaborative Learning*, Villach. pp. 1-6.

- Mayer, I., Bekebrede, G., Hartevelde, C., Warmelink, H., Zhou, Q., van Ruijven, T., Lo, J., Kortmann, R. and Wenzler, I., 2014. The research and evaluation of serious games: Toward a comprehensive methodology. *British Journal of Educational Technology*, 45(3):502-527.
- Mbogo, C., Blake, E. & Suleman, H. 2014. Initial Evaluation of a Mobile Scaffolding Application That Seeks to Support Novice Learners of Programming. *International Association for Development of the Information Society*.
- McTaggart, R. 1991. Principles for participatory action research. *Adult Education Quarterly*, 41, 168-187.
- Miles, M. B. & Huberman, A. M. 1994. *Qualitative data analysis: An expanded sourcebook*. Sage.
- Mikre, F., 2011. The roles of information communication technologies in education: Review article with emphasis to the computer and internet. *Ethiopian Journal of Education and Sciences*, 6(2):109-126.
- Mitamura, T., Suzuki, Y. and Oohori, T., 2012. Serious games for learning programming languages. *Systems, Man, and Cybernetics*, Seoul. pp. 1812-1817.
- Mitchell-Wong, J., Kowalczyk, R., Roshelova, A., Joy, B. and Tsai, H., 2007. Opensocial: From social networks to social ecosystem. *Digital EcoSystems and Technologies*, Cairns. pp. 361-366.
- Mohd, N.I., Ali, K.N., Fauzi, A.F.A.A. and Ebrahimi, S.S., 2018. Serious Game Attributes for the Construction of a Hazard Identification Framework. *International Journal of Interactive Mobile Technologies*, 12(7):60-69.
- Morelli, R., De Lanerolle, T., Lake, P., Limardo, N., Tamotsu, E. and Uche, C., 2011, March. Can android app inventor bring computational thinking to k-12. *Computer science education*, p. 1-6.
- Mouton, J. 2001. Methodological paradigms in social research. The practice of social research. South African Edition. Cape Town: Oxford University Press.
- Mukit, A., 2018, April. Basic Programming Concepts for Beginners. <https://dev.to/lucpattyn/basic-programming-concepts-for-beginners-2o73>. Date of access: 20 Feb. 2018.
- Muratet, M., Torguet, P., Viallet, F. & Jessel, J.P. 2011. Experimental Feedback on Prog&Play: A Serious Game for Programming Practice. *Computer Graphics forum*, 30 (1):61-73.
- Myers, M.D. and Klein, H.K., 2011. A set of principles for conducting critical research in information systems. *MIS quarterly*, 35(1).
- Myers, M. D. 1997. Qualitative research in information systems. *Management Information Systems Quarterly*, 21, 241-242.
- Nag, S., Katz, J.G. & Saenz-Otero, A. 2013. Collaborative gaming and competition for CS-STEM education using SPHERES Zero Robotics. *Acta Astronautica*, 83:145-174.
- Ness, L.R., 2015. Are we there yet? Data saturation in qualitative research. *The qualitative report*, 20(9), p.1408.

- Neuman, W.L. 2011. *Social Research Methods: Qualitative and quantitative approaches*. Boston, MA:Pearson Education.
- Noor-Ul-Amin, S., 2013. An effective use of ICT for education and learning by drawing on worldwide knowledge, research, and experience: ICT as a change agent for education. *Scholarly Journal of Education*, 2(4):38-45.
- Nunes, E.P., Luz, A.R., Lemos, E.M., Maciel, C., Dos Anjos, A.M., Borges, L.C. and Nunes, C., 2016, October. Mobile serious game proposal for environmental awareness of children. *Frontiers in Education*, Erie, PA, USA, pp. 1-8.
- Oates, B.J., 2006. *Researching information systems and computing*. Sage.
- Page, T., 2012, June. Programming 101 - The 5 Basic Concepts of any Programming Language. <https://howtoprogramwithjava.com/programming-101-the-5-basic-concepts-of-any-programming-language/>. Date of access: 20 Feb. 2018.
- Parise, S. and Crosina, E., 2012. How a mobile social media game can enhance the educational experience. *Journal of online Learning and Teaching*, 8(3), p.209.
- Patton, M. Q. 2002. Two decades of developments in qualitative inquiry a personal, experiential perspective. *Qualitative Social Work*, 1(3):261-283.
- Pfeffers, K., Tuunanen, T., Gengler, C.E., Rossi, M., Hui, W., Virtanen, V. and Bragge, J., 2006. The design science research process: A model for producing and presenting information systems research. *Design Science Research in Information Systems and Technology*, Claremont, CA, USA. pp. 83-106.
- Perrotta, C., Featherstone, G., Aston, H. and Houghton, E., 2013. Game-based learning: Latest evidence and future directions. *NFER Research Programme: Innovation in Education*. Slough: NFER.
- Peters, A. & Pears, A. 2012. Students' experiences and attitudes towards learning computer science. *Frontiers in Education*, Seattle, WA. pp. 1-6.
- Petri, G. and von Wangenheim, C.G., 2016. How to evaluate educational games: a systematic. *Journal of Universal Computer Science*, 22(7):992-1021.
- Pivec, M., 2007. Play and learn: potentials of game-based learning. *British Journal of Educational Technology*, 38(3):387-393.
- Pho, A. and Dinscore, A., 2015. Game-based learning. *Tips and Trends*. <https://acrl.ala.org/IS/wp-content/uploads/2014/05/spring2015.pdf>. Date of access: 25 Feb. 2018
- Plass, J.L., Homer, B.D. and Kinzer, C.K., 2015. Foundations of game-based learning. *Educational Psychologist*, 50(4):258-283.
- Pokress, S.C. and Veiga, J.J.D., 2013. MIT App Inventor: Enabling personal mobile computing. <https://arxiv.org/pdf/1310.2830>. Date of Access: 10 Aug. 2017
- Pourabdollahian, B., Taisch, M. and Kerga, E., 2012. Serious games in manufacturing education: Evaluation of learners' engagement. *Procedia Computer Science*, 15, p.256-265.
- Pranantha, D., Bellotti, F., Berta, R. and De Gloria, A., 2012. A format of serious games for higher technology education topics: a case study in a digital electronic system course. *Advanced Learning Technologies*, Rome. pp. 13-17.

- Prensky, M. 2001. The games generations: How learners have changed. *Digital game-based learning*, p.1-26.
- Pretorius, D.L., Goede, R. and Terblanche, J.T., 2016. Action Research or Design Science Research as Methodology for the Development of a Historical Digital Graphical Novel? A Critical Systems Perspective. *59th Annual Meeting of the ISSS-2015 Berlin, Germany* (Vol. 1, No. 1).
- Prinsloo, J.W. and Jordaan, D.B., 2014. Selecting serious games for the computer science class. *Mediterranean Journal of Social Sciences*, 5(21), p.391.
- Rapoport, R.N. 1970. Three Dilemmas in Action Research: With Special Reference to the Tavistock Experience. *Human Relations*, 23(6):499-513.
- Ribeiro, J., Almeida, J.E., Rossetti, R.J., Coelho, A. & Coelho, A.L. 2013. Towards a serious games evacuation simulator. <https://arxiv.org/pdf/1303.3827>. Date of Access: 10 Jun 2018.
- Redd, J.B. and Schmidt, D., 2011. Using mobile devices and gaming as a means of building vocabulary. *International Journal of Interactive Mobile Technologies*, 5(4):30-38.
- Riel, M., 2010. Understanding action research. *Research Methods in the Social Sciences*, 17(1):89-96.
- Rogers, Y., Sharp, H., & Preece, J. 2011. *Interaction design: beyond human-computer interaction*. John Wiley & Sons.
- Rooney, P. 2012. A Theoretical Framework for Serious Game Design: Exploring Pedagogy, Play and Fidelity and their Implications for the Design Process. *International Journal of Game-Based Learning*, 2(4):41-60.
- Rouillard, J., Serna, A., David, B. and Chalon, R., 2014, June. Rapid prototyping for mobile serious games. *International Conference on Learning and Collaboration Technologies*, Springer, Cham. pp. 194-205.
- Saunders, M., Lewis, P. & Thornhill, A. 2009. Research methods for business students. 5th ed. Harlow: Pearson.
- Saunders, M., Lewis, P. & Thornhill, A. 2009. Understanding research philosophies and approaches. *Research methods for business students*, 4:106-135.
- Saunders, M., Lewis, P., Thornhill, A. & Wang, C. 2009. Analysing quantitative data. *Research Methods for Business Students*, in MNK Saunders, P. Lewis, & A. Thornhill (Eds.), *Research Methods for Business Students*, (5th ed.), Prentice Hall, UK.
- Schmitz, B., Klemke, R. and Specht, M., 2013. Effects of mobile gaming patterns on learning outcomes: a literature review. *International Journal of Technology Enhanced Learning*, 4(5-6), pp.345-358.
- Schuetz J., 2018, March. Comparing Game Engines: Unity vs Unreal vs Corona vs Gamemaker. <https://www.pubnub.com/blog/comparing-game-engines-unity-unreal-corona-gamemaker/>. Date of access: 22 Jun. 2018.
- Schwabe, G. & Göth, C. 2005. Mobile learning with a mobile game: design and motivational effects. *Journal of computer assisted learning*, 21, p.204-216.

- Scriven, M., 1998. Minimalist theory: The least theory that practice requires. *American Journal of Evaluation*, 19(1):57-70.
- Seaman, C.B., 1999. Qualitative methods in empirical studies of software engineering. *Transactions on software engineering*, 25(4):557-572.
- Serrano-Laguna, Á., Martínez-Ortiz, I., Haag, J., Regan, D., Johnson, A. and Fernández-Manjón, B., 2017. Applying standards to systematize learning analytics in serious games. *Computer Standards & Interfaces*, 50, p.116-123.
- Shabanah, S. & Chen, J.X. 2009. Simplifying algorithm learning using serious games. *Computing Education*, p. 34-41.
- Shenton, A. K. 2004. Strategies for ensuring trustworthiness in qualitative research projects. *Education for information*, 22(2):63-75.
- Sierra, A.J., Ariza, T., Fernández-Jiménez, F.J., Muñoz-Calle, J., Molina, A. and Martín-Rodríguez, Á., 2016. Educational resource based on games for the reinforcement of engineering learning programming in mobile devices. *Technologies Applied to Electronics Teaching*, Seville. pp. 1-6.
- Sin, Z.P., Ng, P.H., Shiu, S.C. and Chung, F.L., 2017. Planetary marching cubes for STEM sandbox game-based learning: Enhancing student interest and performance with simulation realism planet simulating sandbox. *Global Engineering Education conference*, Athens. pp. 1644-1653.
- Sinicki A, 2018. An Introduction to Unity3D for easy-android game development. <https://www.androidauthority.com/an-introduction-to-unity3d-666066/>. Date of access 22 Jun. 2018.
- Skinner G., 2017, September. CREATEJS. <https://createjs.com/>. Date of access: 21 Jun. 2018.
- Smith, S.P., Hickmott, D., Bille, R., Burd, E., Southgate, E. and Stephens, L., 2015, December. Improving undergraduate soft skills using m-learning and serious games. *Teaching, Assessment, and Learning for Engineering*, Zhuhai. pp. 230-235.
- Sørensen, B.H., 2009, January. Concepts of Educational Design for Serious Games. *Multimedia and ICT in Education*, p. 278-282.
- Spertus, E., Chang, M.L., Gestwicki, P. and Wolber, D., 2010, March. Novel approaches to CS 0 with app inventor for android. *Computer science education*, p. 325-326.
- Stanescu, I.A., Stefan, A. & Roceanu, I. 2011. Interoperability in Serious Games. *eLSE - eLearning and Software for Education*.
- Stanton, G. and Ophoff, J., 2013. Towards a method for mobile learning design. *Issues in Informing Science & Information Technology*, 10.
- Steiner, C., Hollins, P., Kluijfhout, E., Dascalu, M., Albert, D., Westera, W. and Nussbaumer, A., 2015, October. Evaluation of serious games: a holistic approach. *ICERI2015: 8th annual International Conference of Education, Research and Innovation*, p. 4334-4342.
- Straub, D.W., Ang, S. & Evaristo, R. 1994. Normative standards for IS research. *SIGMIS Database*, 25(1):21-34.

- Su, C.H. & Cheng, C.H. 2015. A mobile gamification learning system for improving the learning motivation and achievements. *Journal of Computer Assisted Learning*, 31(3):268-286.
- Sudarsan, P., 1998. Habermas and critical social theory. *Indian Philosophical Quarterly*, 25, p.253-266
- Susman, G.I., 1983. Action research: a sociotechnical systems perspective. *Beyond method: Strategies for social research*, 95, p.113.
- Susman, G. & Evered, R. 1978. An Assessment of The Scientific Merits of Action Research, *Administrative Science Quarterly*, 23(4):582-603
- Szablewski D., 2017. The Awesomest way To Create Even More Awesome HTML5 Games. <http://impactjs.com/>. Date of access: 21 June 2018.
- Tal, I., Ibarrola, E. and Muntean, G.M., 2016. Quality and standardization in technology-enhanced learning. *ICTs for a Sustainable World*, Bangkok. pp. 1-8.
- Tan, B.-K. & Rahaman, H. 2009. Virtual heritage: Reality and criticism. http://papers.cumincad.org/data/works/att/cf2009_143.content.pdf. Date of access: 21 Feb. 2018.
- Tandon, R. 1989. Participatory research and social transformation. *Convergence*, 21(2/3), 5-15.
- Tezci, E., 2009. Teachers' effect on ICT use in education: The Turkey sample. *Procedia-Social and Behavioral Sciences*, 1(1):1285-1294.
- Tinio, V.L., 2003. ICT in Education. [www.academia.edu/download/49568157/ICT in Education.PDF](http://www.academia.edu/download/49568157/ICT_in_Education.PDF). Date of Access: 21 Feb. 2018
- Towey, D., Ricky, Y.-K.N. & Wang, T. 2016. Open Educational Resources (OERs) and Technology Enhanced Learning (TEL) in Vocational and Professional Education and Training (VPET). *Teaching, Assessment, and Learning for Engineering*. Bangkok. pp. 284-288.
- Tsalikidis, K. and Pavlidis, G., 2016. jLegends: Online game to train programming skills. *Information, Intelligence, Systems & Applications*, Chalkidik. pp. 1-6.
- Vaishnavi, V. & Kuechler, W. 2004. Design research in information systems. <http://www.isworld.org/Researchdesign/drIslSworld.htm>. Date of Access: 22 Feb. 2018
- Van Teijlingen, E.R. and Hundley, V., 2001. The importance of pilot studies. *Journal of advanced nursing*, 34(3), pp.289-295.
- Vinciguerra, D. and Howell, A., 2015. *The GameMaker Standard*. CRC Press
- Vogel, J.J., Greenwood-Ericksen, A., Cannon-Bowers, J. & Bowers, C.A. 2006. Using virtual reality with and without gaming attributes for academic achievement. *Journal of Research on Technology in Education*, 39(1):105-118.
- Wagner, D., Day, B., James, T., Kozma, R.B., Miller, J. and Unwin, T., 2005. Monitoring and evaluation of ICT in education projects. *A Handbook for Developing Countries*. Washington DC: InfoDev/World Bank.

Wang, T.L. and Tseng, Y.F. 2014. An empirical study: Develop and evaluation a mobile serious game on environmental education. *Computer Science & Education*, Vancouver, BC. pp. 311-315.

Wilson, K.A., Bedwell, W.L., Lazzara, E.H., Salas, E., Burke, C.S., Estock, J.L., Orvis, K.L. and Conkey, C., 2009. Relationships between game attributes and learning outcomes: Review and research proposals. *Simulation & gaming*, 40(2), :217-266.

Wolber, D., 2011. App inventor and real-world motivation. *Computer science education*, p. 601-606.

Wrzesien, M. & Alcañiz Raya, M. 2010. Learning in serious virtual worlds: Evaluation of learning effectiveness and appeal to students in the e-junior project. *Computers & Education*, 55 (1):178-187.

Yousef, D., Baadel, S. and Makad, R., 2014. Exploratory study on the impact of game-based learning on student engagement. *International conference on Web and Open Access to Learning*, Dubai. pp. 1-4.

Zeeman, M.J. 2014. Modelling the factors that influence computer science students' attitude towards serious games in class. *Unpublished dissertation, NWU*.

Zyda, M. 2005. From visual simulation to virtual reality to games. *Computer*, 38(9):25-32.

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APPENDIX A: Serious Games List in Computer Programming

Name	Description	Links
Coding planets	It is an android game that teaches you the logic behind programming.	https://play.google.com/store/apps/details?id=com.material.design.codin_gplanet&hl=en_ZA
Algorithm city	This is a fun and innovative coding game that teaches children the basics of programming and <i>algorithm</i> . It teaches coding with fun games by using animals.	https://play.google.com/store/apps/details?id=air.MusterenGames.ElHar ezmiCoding&hl=en
Coding planets 2	This is an Educational, Brain training and puzzle game. In this game, a player has to write a program for a robot to solve the puzzles. There are three Programming languages supported and every ages can play.	https://play.google.com/store/apps/details?id=com.material.design.codin_gplanets&hl=en_ZA
LightBot	In this game, the player has to program a robot to light up blue tiles. Each time the objective is achieved, the player advances to the next level.	https://play.google.com/store/apps/details?id=com.lightbot.lightbothoc&hl=en http://lightbot.com/flash.html
Robotizen	This game teaches the basics of computer programming and robotics through a variety of interactive learning activities in an interesting story. Robotizen helps kids to improve their problem solving, logical thinking and creativity.	https://play.google.com/store/apps/details?id=vn.com.mage.irobot&hl=en_ZA
Coddy	This game teaches programming and logic through controlling a robot in a series of puzzles.	https://play.google.com/store/apps/details?id=com.SimplyProjects.CoddyFree&hl=en
Coding Galaxy	This app is a gamified learning application for <i>kids aged from 5 and above</i> or for <i>any programming beginners</i> . With over 200 game-based learning activities, it aids learners in learning basic programming concepts and to develop computational thinking.	https://play.google.com/store/apps/details?id=com.tangoredu.coding&hl=en_ZA https://codinggalaxy.com/en
RoboZZle Droid	RoboZZle is a programming puzzle game. The player has to program a robot to collect all items from 2D tri-colored field.	https://play.google.com/store/apps/details?id=com.team242.robozzle&hl=en
Code combat	Code Combat is a game-based computer science program where students type real code and see their characters react in real time.	https://codecombat.com/
Code wars	This is an educational community for computer programming. On the platform, software developers train on programming challenges known as kata	https://www.codewars.com/

APPENDIX B: Interview Guideline

Pre-evaluation questions:

- Have you ever considered to recommend a serious game to your computer science learners?
 - If yes:
 - Can you briefly describe the game(s)?
 - How did you identify the game?
 - What did you like the most about the game?
 - What did you not like about the game?
 - If No:
 - Why haven't you considered to recommend Serious games in your classroom?
- Do you know of any serious game attributes/characteristics? And if yes,
 - Mention these attributes/characteristics? And,
 - Which of those attributes/characteristics have you considered when selecting a serious game in computer programming and why?
- Do you or would you use a particular method to identify and select a serious game for your computer programming learners/students?
 - If yes, please describe it
 - Have you ever considered any of these attributes in your method? And to what extent?
 - Textual or visual game
 - Feedback mechanism and progress
 - Ability to adjust level of difficulty to the skill-level of the player
 - Player's influence over attributes in the game
 - Safety of the game
 - Perception of game/reality
 - Definition of rules for the game
 - Level of player interaction
 - Rules of a game
- If no:
 - Why wouldn't you use any particular method to select any serious game? Please explain.
 -
- Do you think mobile serious games can help to enhance computer science education? Why/ please explain?

- On a scale of 1-5, can you rate how the following serious game attributes are important in selecting a serious game for learning computer programming concepts:

Category	Game Features (deemed to support learning)	Scale (1-5, 1= strongly disagree and 5=strongly agree)
Action Language	Language/Communication: textual or visual	☐ ☐ ☐ ☐ ☐
Assessment	Assessment: feedback to learn from previous actions	☐ ☐ ☐ ☐ ☐
	Progress: players progress towards the end of the game	☐ ☐ ☐ ☐ ☐
Conflict/Challenge	Adaption: adjust difficulty to skill level of player	☐ ☐ ☐ ☐ ☐
	Challenge: progressive, well balanced difficulty + clear goals	☐ ☐ ☐ ☐ ☐
	Conflict: solvable problems	☐ ☐ ☐ ☐ ☐
	Surprise: random element of the game	☐ ☐ ☐ ☐ ☐
Control	Control: player's power or influence over elements in game	☐ ☐ ☐ ☐ ☐
	Interaction (Equipment): game responds to player's action	☐ ☐ ☐ ☐ ☐
Environment	Location: physical or virtual world the game takes place in	☐ ☐ ☐ ☐ ☐
Game Fiction	Fantasy: make-believe, i.e. take on role or simulate process	☐ ☐ ☐ ☐ ☐
	Mystery: sensory or cognitive curiosity to obtain information	☐ ☐ ☐ ☐ ☐
Human Interaction	Interaction (Interpersonal): competition, acknowledgement	☐ ☐ ☐ ☐ ☐
	Interaction (Social): activity shared with others	☐ ☐ ☐ ☐ ☐
Immersion	Pieces or Players: objects or people included in narrative	☐ ☐ ☐ ☐ ☐
	Representation: perception of game reality, enables focus	☐ ☐ ☐ ☐ ☐
	Sensory Stimuli: temporary acceptance of alternate reality	☐ ☐ ☐ ☐ ☐

	Safety: no consequences other than possibly losing	☐ ☐ ☐ ☐ ☐
Rules/Goals	Rules/Goals: criteria of how to win; need to be well-defined	☐ ☐ ☐ ☐ ☐

1. I found the game features unnecessarily complex. **Yes/No**
2. I found the various game features were well integrated. **Yes/No**
3. I thought the game features were easy to understand. **Yes/No**
4. I think that I would need assistance to be able to understand the game features. **Yes/No**
5. I would imagine that most people would understand game features very quickly. **Yes/No**
6. I thought there was too much inconsistency in the game features. **Yes/No**
7. I found the game features very cumbersome/awkward to understand. **Yes/No**
8. I felt very confident understanding the game features. **Yes/No**
9. I needed to learn a lot of things before I could understand the game features. **Yes/No**
10. Is there anything else you would like to add?

Post evaluation questions:

Please respond to the following statements:

- *I found the game selection process unnecessarily complex. **yes/no***
 - *I thought the game selection criteria model was easy to use. **Yes/no***
 - *I think that I would need assistance to be able to use the selection criteria model. **Yes/no***
 - *I would imagine that most people would learn to use the selection criteria model very quickly. **Yes/no***
 - *I thought there was too much inconsistency in the selection criteria model. **Yes/no***
 - *I found the selection criteria model was very cumbersome/awkward to use. **Yes/no***
 - *I felt very confident using the selection criteria model. **Yes.no***
 - *I needed to learn a lot of things before I could use the selection criteria model. **Yes/no***
- How often would you use this framework of serious game attributes to select a serious game for your class?

- Is there anything else to add?

APPENDIX C: Participants' Sample Response Transcripts and Notes

Topic	Interview A	Interview B	Notes
Game recommendation to learners	<i>Yes, serious games yes so basically, what we did was to recommended one game which is stats for statistic students which was developed here at Northwest university.</i> <i>Yes, serious games yes, so basically, what we did was to recommended one game which is stats for statistic students which was developed here at Northwest university.</i> <i>That was the previous version so it was called stats venture yes that's for statistics students but you know on the computer science module it has statistics students and we also have programming students under one class so basically because it was developed here that's how you recommended it</i> <i>And also Mandela 27, if you know it I won't say it is a serious game that much because you don't get to play it but you select a story; story line playing type of game on story board so it teaches you history so that we knew their history.</i> <i>In Mandela 27 I like the fact that it teaches you if you don't know the</i>	<i>Honestly, I haven't; I am aware of one of the Something combat, something code combat or called stuff like that but it didn't really interest me because usually when I try to think of what the students want and what will help the students, I think about what would have helped me to learn programming and that specific game, that's the only one I know about, I didn't think it would have been helpful to me any other case.</i>	Inhouse. Recommendation. Lack of interest. Helpfulness of SG.

	history of Mandela and what happened in prison I like the fact that it teaches you that history and to know what happened to those years during apartheid years what took place in the prison system you know and all of those things; the stats one I didn't really like it that much for me it was too basic it was just drag-and-drop type of a game of course it teaches you something but it was too basic that's why they needed to develop another version of it		
Knowledge on SG attributes	What I do understand about serious games is that they have to have some kind of interaction component between the user in the game so the user must interact with the game so they get to learn something and also is that educational aspect the games at the end of the day they should educate the user they should impart some knowledge on the user and it's just not only for fun so, the other thing the interaction part it's important; visuals are not that sure yes you can have nice visuals but remember the main point of serious games is to educate; so yes it can look nice and all but I don't think they do play that important part.	Not really, I don't have any knowledge of it you know a lot of students lectures they like to play games I'm not a gamer I have one game I play on my PC every few months city skyline building a city designing your own layout years ago I played Sims. I'm not a big gamer. I feel like City skyline is more like a strategic game but it's not it's not like you have to complete missions or there's a specific guideline to what you need to do in the game for example when you play something like a shooting game you probably have missions. I'm not even sure but with a city skyline it's just you build your city the way you want to build it and if You	Player interaction. learning attribute. Lack of knowledge. Not a gamer. Virtual world.

		feel like not playing anymore. You don't really have to complete. Yeah, another game I actually play on game is you know flappy bird that's like I love that game it keeps my hands busy for a little while.	
Methods for serious games	<i>I haven't had a chance to search and find the best methods to select a serious game for computer science students.</i> <i>I haven't had a chance to search and find the best methods to select a serious game for computer science students.</i> <i>But we do help to teach students of the extended program how to program simple games; the basics of programming and some basic components of serious games they can use and what to expect from a serious game and the interaction components and how it should look like the design principles in all of those we teach them nothing yes okay.</i> <i>For instance, you get students that haven't done program in their life or they haven't coded before so what we do is we teach them using simple environments for example scratch you don't necessarily need to write code but you just drag and drop blocks of codes into a program to design a game so that's a very</i>	<i>I think it is you know what like the code combat, because it's the only one I know and I'm not that familiar with the game to have only been introduced to it briefly but I feel like it's another thing that they need to figure out how to use the game and I have students in the first year that are not familiar even with how to use a computer.</i> <i>Yeah, they don't I remember last semester With the Python module we did exile briefly for the first two weeks and it</i> <i>Was a struggle just to have them understand how to navigate the computer like where the backspace button is how to change font how to do very basic things that I think are basic to us so that's why I feel like the games will just add a level of complexity that's unnecessary rather stick to the basics and try to focus on the programming itself and not figure out</i>	Lack of time. Lack of knowledge. More learning required.

	<i>simple approach that helps students understand this programming concepts before they even get to platforms like java they already know an if statement but they don't know how to actually, code the if statement but they know the block of an if statement and what it does the knowledge.</i>	<i>how to play the game does that make sense.</i>	
Importance of serious games	<i>so yeah, I do think serious games they do help students because yes you get games that are very basic that teach basic things</i>	<i>Yes, but I think it's the opinion of the student I feel like students who are on a more advanced level might be able to have fun with it and learn new concepts but students who are also struggling to grasp the basics might have a more difficult time okay but that's only my opinion</i>	Fundamental learning. Students' interests. Level of experience.