Scrum Requirements Engineering for a Game-based Learning Web Platform for Grade R – 12 Learners in South Africa

By

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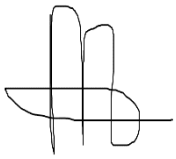
Declaration

I, **Makhasane Precious Mamotheti**, declare that the contents of this thesis represent my own unaided work and that the mini dissertation/thesis has not been previously submitted for academic examination towards any qualification. Furthermore, it represents my own opinions and not necessarily those of the Cape Peninsula University of Technology.



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Abstract

There is a consensus through literature that Game-Based learning (GBL) platforms are effective learning tools. Games are always of interest to the younger generation because they serve as a mode of entertainment. However, while providing entertainment, games can also provide additional benefits such as education. A gamified environment can provide a blend of serious learning while making it fun for learners. Some researchers have observed that GBL could stimulate valuable educational outcomes and positively impact a child's life. Although research on GBL has gained popularity in most foreign countries, GBL has not really found its feet in South Africa as an alternative tool to enhance the education environment. Evidence shows that Learners in poor communities in South Africa (SA) are performing poorly academically due to poor student engagement and lack of motivation. Learners in SA, especially the ones from disadvantaged communities need Game-based learning tools to enhance their learning.

Therefore, the aim of the study is to identify the requirements needed to build a game-based learning web platform for grade R – 12 learners in South Africa particularly in township schools. A survey was conducted involving participants from 5 South African Schools (2 Primary and 3 Secondary schools) to determine the requirements needed for GBL web platform in SA for disadvantaged learners. A total of 244 students and 37 teachers participated in the survey.

Based on the study's objectives: (1) To determine the type and mode of GBL that is relevant to Grade R-12 students in South Africa. (2) To design a RE framework for a GBL web platform based on Scrum. (3) To demonstrate how to apply the Scrum-based RE framework for specification on requirements for GBL web platform for grade R-12 learners. (4) To demonstrate how to apply the Scrum-based RE framework for specification on requirements for GBL web platform for grade R-12 learners.

This study adopts Design science research (DSR). The research design mapped the phases of DSR to how the Requirements Engineering (RE) Framework was created. Requirements elicitation, which is awareness of the problem, was initiated by sending out a survey to 5 schools. Based on the survey results, most learners see themselves as verbal or social learners, friendly or talkative in terms of personality, only a few said to be quiet and shy. For their learning style, most learners prefer to learn verbally and socially, while some prefer solitary learning. Most learners play games and enjoy playing games, mainly using smartphones. The study found the learners' preferential order of type of games are puzzles, video games, simulation games, word games, and card games. The aspects of visual aesthetics, musical scores, and incentive appeal to most learners. At the same time, there is also a preference for games that involves a challenge, enable competition with peers, and promotes curiosity.

Based on the results of requirements elicitation, Scrum RE Framework was designed. The framework defines the process to be followed using Scrum to gather the requirements needed to build a game-based learning system. With the guidance of the Scrum RE framework, Scrum sessions with learners and teachers commenced to formulate user stories to identify, verify and prioritize the requirements. Requirements prioritization was done using MoSCoW techniques.

After requirements prioritization, the requirements were then identified in phase 3(Development phase) of DSR. The requirements identified were presented to a group of specialists for evaluation. The requirements were evaluated based on Weiger's requirements quality model and Pohl's requirements quality model. System analysts (SA), Business Analysts (BA), and Developers rated the attributes of the requirements and found that; the individual attributes values; Complete, Traceable, Comprehensive, and Consistent are rated very good. Furthermore, the individual attributes; Verifiable, Rated/Prioritize, and Up to date are rated to be very good as well. For Atomic and Unambiguous, attributes were found to be good. While as a set of requirements, the attributes were rated very good for all attributes, thus for Completeness, Consistency, Modifiability, Traceable, and Readability. Meaning Most of the evaluators found the requirements a set to be very good.

Keywords: Game-based learning; Game design; Gamification; Requirements Engineering, Agile methodology; Scrum activities, South African Education; Teaching styles; Requirements prioritization.

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Dedication

This goes out to my mother, my pillar of strength. Mokgadi Mamotheti and my son Neo Mamotheti for the selfless love and support they have shown me throughout my academic journey. I will be forever grateful for their prayers, love, support, and words of encouragement, which gave me the strength to persevere until the end.

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Glossary

Terms/Acronyms/Abbreviations	Definition/Explanation
GBL	Game-based learning
DGBL	Digital Game-based learning
RE	Requirements engineering
Scrum	Agile methodology that provides a process model to develop products
TIMSS	Trends in International Mathematics and Science Study
IBL	Inquiry-based learning
RM	Requirements Management
ASD	Agile software development
UCD	User-centered design
UX	User experience
JIT	Just in time
JAD	Joint application development
PO	Product Owner
TEL	Technology-enhanced learning
DSR	Design science research
DSDM	Dynamic software development method
BA	Business Analyst
SA	System Analyst

1. CHAPTER ONE: INTRODUCTION

1.1. Background to the study

Games have evolved to be a sport of interest amongst young generation today (Arifudin, Sulistiyaningsih, & Kautsar, 2020; Avidov-Ungar & Hayak, 2021; Aziz, Subiyanto, & Harlanu, 2018). These days more and more learners grow up using technology devices such as computers, smartphones, and play-stations to perform all sorts of activities (Dimitra et al, 2020). The one activity that is common is playing games on these devices. In a week, it is said that young people spend an average of 7 hours playing games (Anderson, 2019). As much as games provide entertainment to young people, it can also provide other benefits such as education (Mohanty et al., 2021). Therefore, it is important to take advantage of young people's interest and excitement in playing games to motivate them for serious learning.

The use of digital games has been proven to be efficient and effective in student learning. Without even realising it, students use digital games to learn, which makes these games the perfect tool to use in student learning (Dimitra et al, 2020). Hence, there is a shift towards using digital learning in classrooms rather than traditional learning. These digital learning environments offer an opportunity to transform the teaching process using game elements to help motivate goals, stimulate users' attention, facilitate effective teamwork, promote competition, and help in communication (Subhash & Cudney, 2018).

For most learners to be motivated to enthusiastically participate in the learning process, they need effective and interactive experiences (Behnamnia, Kamsin, Ismail, & Hayati, 2020; Byun & Joung, 2018). One way to do this is via digital gamed based learning. The use of a digital learning environment through games is called Game-based Learning (GBL). Game-based learning (GBL) is defined as the use of game mechanics by learners where they engage in comprehensive learning experience through interactive cycles of assessment and feedback (Williams, 2019). Gaming as a tool for learning is not a new concept in the education space, but in recent decades, it has evolved as a computer technology and has become more common (Williams, 2019).

GBL is important because of its elements such as perseverance, player engagement, adaptivity, and graceful failure which helps in encouraging players to persevere when playing the game, thinking out of the box, and learn from their mistakes and adjust accordingly (Williams, 2019). Typically, Students find games attractive/fun, the majority of teachers are exploring ways to incorporate educational games into the classroom (Spires & Lester, 2015).
Connolly et al. (2012) found that the outcomes for using serious games for learning is motivation, improved knowledge achievement and content expert. It is found that GBL has a positive effect on student engagement. GBL is used to make the learning process to be more interesting by encouraging students to participate in learning while playing games which makes it fun (Al-Azawi, Al-Faliti & Al Blushi, 2016).

Educational games were introduced in most classrooms to help students learn and improve their learning because of the above-mentioned key elements. Most grade R-12 learners find it difficult to love and enjoy

learning because of the challenges in their curriculum. Major issues faced by teachers in schools are poor student engagement and a lack of motivation (Lee & *Hammer*, 2011; Subhash & Cudney, 2018; Robberts & Van Ryneveld, 2022). As a result of this difficulty grade R-12 learners are facing, game-based learning (GBL) evolved as measure to help in student learning (Subhash & Cudney, 2018).

Students in South Africa (SA), especially the ones from disadvantaged communities need game-based learning tools to enhance their learning. Research has shown that learners from poor economic backgrounds in South Africa perform worse academically (Spaull & Kotze, 2015; Francis & Webster, 2019). In South African education, there is an on-going crisis, and the current education system has failed to address the needs of majority of South African youth (Spaull, 2015). Based on independently conducted assessments, Spaull (2019), reported that excluding the wealthy minority, a bigger part of the South Africans population is functionally illiterate and innumerate, while most South African pupils cannot read, write, and compute at a level equivalent to their grade.

In 2004,72% of grade 6 failed the national literacy test, the figure was substantially higher in Mathematics, where 88% of all the Grade 6 learners are failing to achieve the curriculum standard (Taylor, Fleisch & Shindler, 2007). The score in international studies including Trends in Mathematics and Science (TIMSS) places the Grade 8 learners in South Africa at the very bottom of the 50 participating countries. Although there has been some improvement in TIMSS, Mathematics is still an issue for South African learners as the international statistics show that they perform at an average in Mathematics when compared to other learners of the same grades in other countries (Bosman & Schulze, 2018; Spaull, 2019). While there are signs of improvement in performance in mathematics, even the most optimistic commentators agree that there is still a long way to go for South African learners to get the correct standard for mathematics (Van der Berg & Gustafsson, 2019). It is still a truism that most learners of South Africa poorly perform mathematics (Taylor, 2021)

Comparative data generated nationally, regionally, and internationally, show that SA learners' low levels of numeracy have a negatively affected their learning of mathematics in higher grades (Morrison, 2018; Taylor 2021). More recent research shows that despite the apartheid policies changes that used to have prevent Black Africans receiving quality education, to date Black Africans continue to underperform in subjects like science (Mupira & Ramnarian, 2018). The authors in an to attempt to solve this problem, they investigated the effect of inquiry-based learning (IBL) which tries to motivate a learner in their studies by learners engaging in an authentic scientific discovery. They found that 22% of the white learners in Matric achieve 60% or above, while only 3% of the Black and Coloured group achieve the same level is the Whites (Spaull, 2019). The quality of South African standard of education in schools is at a level typically the same as low-income countries rather than middle- income countries (Van der berg, Gusfasson & Malindi, 2020)

Furthermore, there is a high dropout rate of learners in schools, as well as the fact that in South Africa, the overall progress in schools is slow, 52% of learners repeat a grade at least once before they reach Grade 10 (Grossen, Grobler & Lacente, 2017). However, there is an improvement by 10% in learner's dropout

rate in 2022 as compared to 2019 before Covid-19 (Masson, 2023) The majority of Black and Coloured learners still perform poorly as compared to poorer African countries (Van der Berg & Hofmeyr, 2018; Spaull, 2019). There is substantial amount of evidence on the education crisis in SA particularly in the disadvantaged communities.

As the literature has already proved that GBL can help learners to improve in their school subjects can help South African grade R-12 learners by creating a positive influence in particular subjects like mathematics and science (Hainey et al., 2016; Byun & Joung, 2018; Gao et al., 2020). Therefore, to help address the educational crisis in SA, this study seeks to explore the requirements needed to develop a web game-based learning system for grade R-12 learners by using Scrum. Requirements engineering process is followed to identify the requirements for GBL.

It is very challenging to find a satisfactory definition for requirements engineering (RE), because of the inter-connectedness of the requirements with other aspects of the systems engineering and project management (Dick, Hull & Jackson, 2017). RE is a system engineering subset that defines the system at successive levels of abstraction by discovery, analyzing, qualifying, developing, tracing, communicating, and managing requirements (Alsanoosy, Spichkova & Harland, 2020).

RE is very important in the software development life cycle. It is the starting point of the software development lifecycle, meaning changes in requirements will be very costly and time consuming (Darwish & Megahed, 2016). Furthermore, errors in requirements specifications lead to a defective system architecture, which is because of failure in determining accurate requirements. In most cases, software development environments are characterized by user request to make changes to the requirements. The problem of constantly changing requirements can be effectively tracked by using an agile methodology such as Scrum. Scrum's ability to deal with changing environments has made the methodology to gain great attention and hence the use of scrum in this study.

Scrum is an agile methodology that provide a process model to develop products (Schon, Thomaschewski & Escalona, 2016). Agile Scrum methodology is adopted by organizations to obtain a return on investment quickly on application development, for customer satisfaction improvement and to maintain competitive advantage (Koka, 2015). The other advantages of using scrum are:

i) It is easy to incorporate rapid changes because it involves continuous increments and repetition in the work to be done.
ii) the changes are reversible, and it is cost saving.
iii) Scrum 's main important factor is to provide quality outputs/results; and
iv) At every stage, Scrum enables customer involvement, most of the time the end product developed are customer friendly (Waheed et al., 2018).

Therefore, this study seeks to identify the requirements of game-based learning web platform for grade R-12 learners in South Africa particularly by using the Scrum method.

1.2. Research Problem

Although game-based learning has been identified as a possible solution to the challenges of learning that grade R-12 learners have, a thorough understanding of the requirements of a game-based learning web platform is lacking (Mohanty, 2021; Mosiane & Brown, 2020; Bolstad, 2018). A lack of understanding of these requirements will prevent a successful development of an efficient and effective gamed-based learning (GBL) system to help grade R-12 learners.

So far, many grade R-12 learners in South Africa have continued to struggle in their attempt to learn certain subjects like Maths and Science, which have proved to be more of a challenge to these students than other subjects (Manamela, 2021). Teachers are also frustrated by the difficulty and struggles of learners to learn these subjects, particularly those from disadvantaged backgrounds.

This has negatively affected the learning and progression of learners in the foundation, intermediate and senior educational stages. It has also affected the matric subject choices of learners, and their performance in matric examination in a negative way (Manamela, 2021). This poor performance collectively affects the teachers, learners' matric pass rate and their overall performance of schools in matric results (Taylor, 2021). Although, GBL can contribute to helping South African grade R-12 learners to improve their learning, the detailed requirements of GBL web platform to aid learning are not yet known.

1.3. Aim, Objectives, and Research Objectives

1.3.1. Aim of the Research

The aim of this study is to identify the requirements of a game-based learning web platform for grade R-12 learners in South Africa using the scrum approach.

1.3.2. Research Objectives

The following are the objectives of the study:

1. To determine the type and mode of GBL that is relevant to Grade R-12 students in South Africa.
2. To design a requirement engineering (RE) framework for a GBL web platform based on Scrum.
3. To demonstrate how to apply the Scrum-based RE framework for specification of requirements for GBL web platform for grade R-12 learners.
4. To evaluate the quality of the requirements obtained through the application of the Scrum-based RE framework for GBL web Platform for grade R-12 learners.

1.3.3. Research Questions

1.3.3.1 The main research question of this study is:

What are the requirements for a game-based learning platform for grade R-12 learners in South Africa?

1.3.3.2. The sub-research questions are the following:

1. What are the considerations for the design of a Scrum RE framework for game-based learning platform for grade R-12 learners?

2. How can a Scrum RE framework for a game-based learning platform for grade R-12 learners be designed?
3. How can a Scrum RE framework be applied to identify the requirements for a game-based learning platform for grade R-12 Learners?
4. What are the quality attributes of the requirements of a game-based Learning web platform for grade R-12 learners?

1.3. Delineation of the study

Due to the complexity of requirements gathering and taking to account scrum methodology that was used, which mainly focuses on project delivery in small portions, only five schools in the Western Cape province participated in the study.

1.4. Significance of the study

The study extends the knowledge that already exist about GBL through the application of scrum RE for the design of a web GBL learning in the context of South Africa. It will give recognition to the relevant stakeholder on the importance of Game-based learning. As well as help improve the Grade R-12 learning and their pass rate, which will in-turn help teachers in the classroom.

1.5. Thesis structure

The study was structured into six chapters, each section represents a distinct aspect of the study.
Chapter one introduces the entire study, from the first to the last chapters. Chapter two provides review of literature related to the study, highlighting the theoretical background which provide knowledge about the study and related work which provides gaps and unique contribution for the study. Chapter three discusses the research methodology that was employed in the study, as well as the research design, data collection and data analysis methods. Chapter four explains how requirements engineering activities are applied using Scrum methods to design Requirements Engineering framework. Chapter five presents in detail how the requirements were evaluated by experts in the field of software development. As well how Requirements Management (RM) was done to amend the list of requirements based on the evaluation of the experts. Chapter six finally provides a conclusion about the study, a summary of the study, implications and future research directions are presented.

2. CHAPTER TWO: LITERATURE REVIEW

This chapter presents the theoretical background for the study and a review of related work. The theorical background covers the topics the GBL concepts, characteristics, and other aspects of GBL, while the related work gives an overview of previous research efforts in relation to the aim of this study.

2.1. Theoretical background

2.1.1. Game-based Learning (GBL)

Game-based learning (GBL) is defined as pedagogical learning method where digital and non-digital games are used in educational context to support learner's cognitive development and knowledge acquisition (Adipat et al., 2021). GBL has the ability to improve how learning content is taught because of the learning process where student have a better control of learning while playing games (Martí-Parreño, 2019).

GBL received great attention in the educational space as a tool to help in student engagement and motivation (Hosseini, Hartt & Mostafapour, 2020; Subhash & Cudney, 2018). In a recent study it highlights that the most particular feature that GBL environment has, is to create learning capabilities that are both effective and engaging (Emerson et al., 2020).

The term Game-based Learning (GBL) incorporate all types of learning that involves games, including gameplay, game design and gamification (Bolstad, 2018). These three terms are defined as follows: Gameplay is when topics and ideas are treated as actions, rules, actions, decisions and consequences, rather than as content to be communicated and assimilated (Perrotta, 2013).Through interactions and simulation video games can allow learners to engage with topics and ideas, rather than through the conventional materials and formats of schooling, like textbooks, lessons, assignment and so forth (Perrotta, 2013).

Game design is defined is as the creative use of activities to design and aesthetics use of games for entertainment, educational, exercise or experimental purposes (Wikimedia, 2021). Game design incorporates a wide range of activities related to game development, such as aesthetics, mechanics, story, and technology.

There are many kinds of aesthetics, this includes but not limited to the eight listed (Hunicke, LeBlanc, & Zubek, 2004; Xin, 2022):

1) Sensation: Is known as sense-pleasure in game.
2) Fantasy: Is known as make-believe in game.
3) Narrative: Is known as drama in game.
4) Challenge: Is known as an obstacle course in game.
5) Fellowship: Is known as a social framework in game.
6) Discovery: Is known as uncharted territory in game.
7) Expression: Is known as self-discovery in game.
8) Submission: Is known as a pastime in game.

Principles and elements of game design are increasingly being applied to other interactions in a form gamification (Hunicke, LeBlanc & Zubek, 2004; Xin,2022).

Lastly, the term gamification has emerge in 2008 and has gained popularity since 2010s (Deterding et al., 2011; Seaborn & Fels, 2015). It is important to note that gamification definition vary and normally focus either on game elements and mechanics or the gaming process in serious context (Krath, Schurmann & Korflesch, 2021). Gamification is defined as when elements of a game design, game mechanics and game thinking are used in non-game context for the purpose of motivating participants (Al-Azawi, Al-Faliti & Al-Blushi, 2016). Examples of game elements are: badges, points, levels, leaders, avatars, guests, social graphs or certificates (Zainuddin et al., 2020).

The overall difference between gamification and game-based learning is in the separability of elements of the game in the game related products. Gamification does not necessarily require complete forms of games, rather it involves separable gamifying of game elements. While game-based learning involved using complete serious games for educational purposes (Zhang & Yu, 2022).

Advocates who support GBL argue that games have a positive influence on student's learning by providing a learning environment that is intrinsically motivating and engaging for students in ways that traditional school cannot (Papastergiou, 2009).To date Researchers still support and have proven that GBL can help aid motivation and engagement of learners and also develop the necessary skills for them to learn (Kapp,2012 ; Subhash & Cudney, 2018; Patrick, 2018; William 2019).

Prensky (2001) 's book, upon its release had an impact on the discussion of GBL and to date, it has still an impact. The author strongly supports the idea that the traditional teaching methods should be replaced, and learning should be centred on digital platforms and games, he claims that the earlier generations as compared to the future generations, which he calls digital natives think differently (Lindgren, 2018). After 20 years digital game-based learning is no longer a new tool in the field of education research (Mohanty et al., 2021)

Connolly et al. (2012) found that the outcomes for using serious games for learning is motivation, improved knowledge achievement and content expert. It is found that GBL has a positive effect on student engagement. GBL is used to make the learning process to be more interesting by encouraging students to participate in learning while playing games which makes it fun (Al-Azawi, Al-Faliti & Al Blushi, 2016).

There are certain elements that makes GBL interesting for children to learn. The argument for the use of GBL is that it keeps learners motivated, it encourages player engagement and player adaptivity and then finally it promotes graceful failure (Plass, Homer & Kinzer, 2015; Williams, 2019). There is a relative model to the elements of GBL which illustrates how GBL makes it interesting for children to learn. Figure 2.1 illustrates the GBL Model.

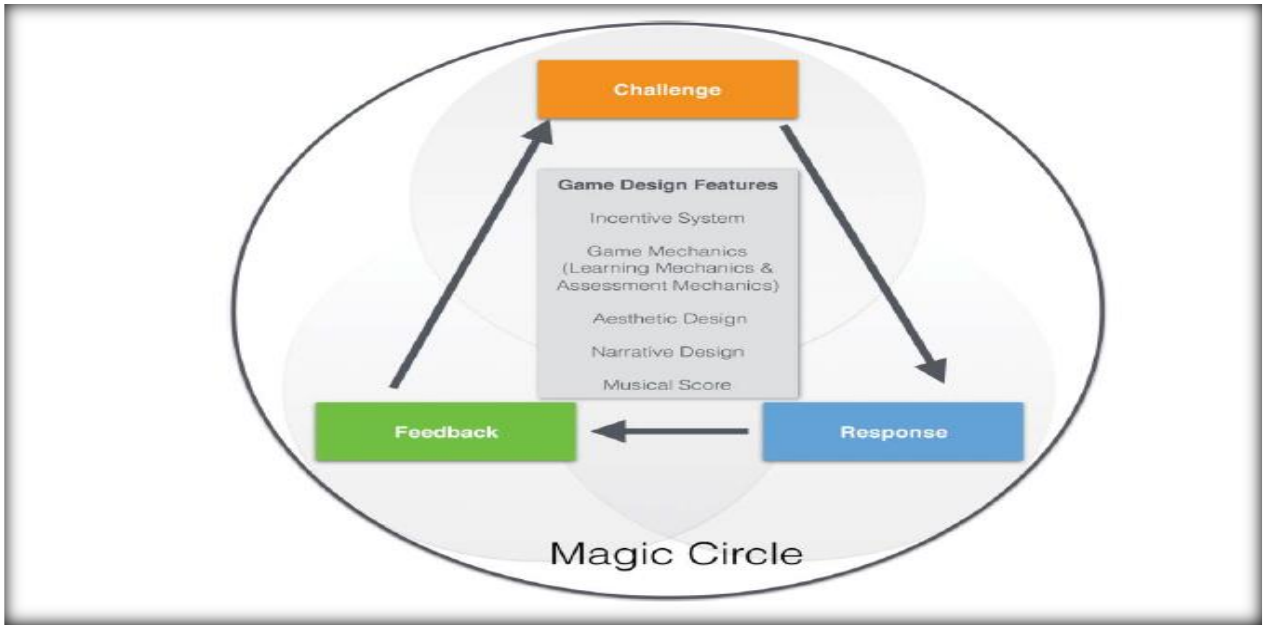

Figure2.1: Game based learning model (Plass, Homer & Kinzer, 2015)

A study by Allop & Jessel; (2015) which was done in both England and Italy primary schools, highlighted reasons for considering using digital games in the classrooms for educational purposes. Figure 2.2 illustrates the reasons to consider GBL in the classrooms.

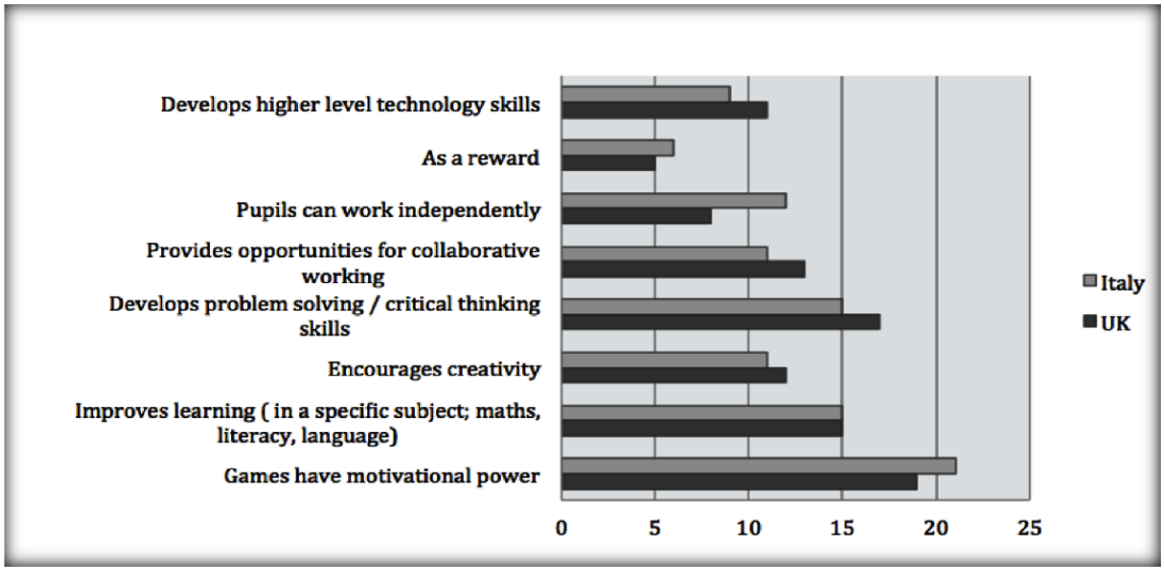

Figure 2.2: Reasons for GBL in Classrooms (Allop & Jessel, 2015)

2.1.2. Teacher's perception

Teachers 's attitudes towards using digital games also plays a vital role in the use of GBL in the classrooms. The acceptance of GBL by teachers strongly influences the adoption and the effectiveness of GBL (Bourgonjon et al., 2013). If teachers have negative views about technology as a whole that can be an important barrier to using digital games for learning in the classrooms (Ertmer, 2005; De Grove, Bourgonjon & Van looy, 2012).

The perception of teachers on digital game's usefulness might be the cause of why there is a limited application of digital games in education (Huizenga et al., 2017). However, the authors say that in most of the studies on teaching with the use of digital games, the participants are teachers who do not actually use digital games in their classrooms. For those teachers that use digital games in the classrooms, the teachers have positive observations about using games to help aid the learning and motivation results.

Various research done on those teachers who games in the classrooms found that the reason why these teachers use games in their classrooms is because games support learners' engagement, learning and motivation to learn (Allsop et al., 2013; Can & Cagiltay, 2006; Ince & Demirbilek, 2013; Li, 2013; Pastore & Falvo, 2010; Ruggiero, 2013; Sardone & Devlin-Scherer, 2008).

The findings of Huizenga et al. (2017) confirm that teachers views are of value when using games to teach in ecologically valid situations. In a recent study, there is a debate about teachers 's views on GBL as an effective approach in educational practices (Chen et al., 2020). Teachers often acknowledge the effectiveness of games in the classrooms; however, they complain about the difficulties of completing the instructional design involved in GBL, which makes it difficult for them to take advantage of GBL (Chen et al., 2020). Fortunately, there are those teachers who are the asking right questions when it comes to improving the learning in the classrooms: "How do we engage with students on their level?", digital game-based learning (DGBL) could be one of the answers to this question (Mohanty et al., 2021).

2.1.3. Challenges of game-based learning

Even though teachers are willing and confident about learning computer skills in relation to "Serious gameplay", thus GBL project (Beavis, 2017:1), the fear of using digital games in classrooms to teach does exist (Pivec, 2009; Zhu & Wang, 2018). Furthermore, there are concerns that teachers personal experience with GBL could affect the adoption of GBL in the classrooms negatively (Meredith, 2016).

In another studies it is noted that teachers cannot be expected to use GBL in their classrooms if they do not have confidence in the ability to use GBL effectively in their classrooms to enhance learning (Becker, 2007; Chen et al., 2020). Teachers who have experience in the use of technology will influence and lead learners to make use of technology than those teachers who have less experience (Felicia, 2014).

Based on a small-scale, for grade R -12 learners, some studies highlight the infrastructure and organization difficulties involved in using serious game in the classroom, the most cited barriers come from the difficulties

in the adaption of academic changes which GBL entails. Research on learners' perspectives on GBL, which focused on grade R-12 learners, has shown that attitudes and experience of games can also present difficulties (Felicia, 2014).

2.1.4. Learners' Education in South Africa

As much as learners are struggling in their school curriculum particularly Mathematics and Science (Spaull, 2019; Taylor, 2021). In recent years 2015 and 2019, there has been an improvement in the Trends in International Mathematics and Science study (TIMSS). TIMSS is conducted every four years by Grade 8 or Grade 9 level since 1995 (Soudien, Reddy & Harvey, 2022). In the recent cycle of TIMSS, from TIMSS 2003- 2011, South Africa recorded an increased average mathematics score, furthermore another increase was recorded in TIMSS 2015- 2019. This achievement improved by 102 TIMSS points or one standard deviation between 2003 – 2019 (Reddy et al., 2020).

The TIMSS 2019 mathematics average score of 389(SE 2.3), which basically means four out ten learners have indicated that they have acquired the minimum mathematical proficiencies. This TIMSS statistics shifted the country's education outcomes from very low to low. Despite these developments, the statistics for TIMMS are still low. Certain factors influenced the TIMSS 2019 which reflects South Africans educational achievements which continues to be linked to race, socio- economic background, and geographic location (Reddy et al., 2020). Furthermore, TIMSS 2019 show that learners from disadvantaged backgrounds still perform at lower level as compared to their advantaged counterparts.

More than two years after the first case of COVID-19 was detected In South Africa (SA), the pandemic continues to present severe challenges to the education sector (Vale & Graven, 2022). With a loss of 42% of official school days in 2020 after COVID-19 hit SA, plus with the rotational system (social distancing) adopted once the schools were opened, which many schools continued with until 2022, half of the learners attended on any given day (Hoadley, 2020). This situation took South African education back because of less teaching and learning during that period. The results likely reflect more than a tally of days loss (van der Berg et al.,2020). One of the main setbacks is existing social and educational inequalities due to a massive disparity in access to educational resources at home (Vale & Graven, 2022). These inequalities continue to be reflected in the TIMSS 2019 results (Reddy,2021). The author's article highlighted how South Africa is improving, but the pace of improvement is slowing, especially after the COVID-19 pandemic.

Research has proven that digital game-based learning (DGBL) can help students to learn better, improve academic performance, motivation and interest, as well as facilitate more acquired knowledge by learners (Grivokostopoulou et al, 2019; Hwang & Chang, 2020; Bhandari, Hallowell, & Correll, 2019; Chang et al, 2020; Kao, 2020; Lee et al, 2016).The major challenge in rural communities is encouraging learners to study as these areas lack proper teaching facilities (Mohanty et al., 2021). It is deduced that in the rural teaching system, application software can prove to be a viable addition (Mohanty et al., 2021). Hence, this study looks at requirements needed to build the application software, GBL platforms in South Africa to help in student learning.

2.1.5. Scrum Requirements Engineering (RE)

Scrum Requirements Engineering will be used to gather and analyse data for this study. The process models in software development have moved from plan-driven to value-driven (Schon, Thomaschewski & Jose`- Escalona, 2016). Requirements engineering (RE) is the process of determining what the customers' needs from a system and constraints for which the system must operate under (De Lucia & Qusef, 2010). Agile software development (ASD) is the use of manoeuvrable yet sufficient rules in a project behaviour, as well as human and communication-oriented rules. What makes a development process agile is when software development is incremental, cooperative, straight forward, and adaptive (Abrahamsson et al.,2017).

The difference between RE and ASD is, RE is the process of creating requirements specification for the purpose of knowledge sharing for all stakeholders involved, while ASD focuses on face-to-face interaction with stakeholders to reach a similar goal (De Lucia & Qusef, 2010). Requirements are based on software products and RE plays an important role in the system development of the products (Schon, Thomaschewski & Escalona, 2016). ASD has evolved to help with the increasing complexity in software development. The application of hybrid development with the integration of user -centered design (UCD) is aimed at delivering competitive products with suitable user experience (UX). Therefore, making RE essential because during RE because stakeholders and users are involved in the development of the production in collaboration sessions. In Agile Requirements Engineering, the focus is on the end results and how these results produced can achieve human needs.

In the Agile methodology context, during the entire development process, requirements engineering (RE) is carried out iteratively instead of closed phases. This is where the Just in time (JIT) model is used to breakdown complex requirements into simple tasks that can be implemented by developers. JIT Model is based on artefact and begins with capturing requirements in the form of epics (Large User stories). Even though Agile methodology and RE seem to be incompatible because Agile methods are people driven while RE is mostly documentation driven, still agile methods in general and scrum to be specific can bring benefits to RE techniques (Darwish & Megahed, 2016). Interviewing, Joint application development (JAD), modelling, wireframes, and documentation are examples of RE practices in scrum approach (Darwish & Megahed, 2016).

According to Darwish & Megahed (2016) Scrum Requirements Engineering (RE) is used mainly for the purpose of identifying user's needs and then documenting it in a way that can be analysed, communicated, and implemented correctly. The authors highlighted five main activities of a Requirements Engineering: Requirements Elicitation, Requirements Analysis, Requirements Documentation, Requirements Validation and Requirements Management Framework.

I. *Requirements elicitation* is a computer-based process for seeking, uncovering, acquiring, and elaborating requirements according to customer's needs and wants (Zowghi & Coulin, 2005; Laplante & Kassab, 2022).

II. *Requirements Analysis* is the analysis of the elicited requirements for the purposes of understanding and then document them (Chazette, Brunotte & Speith, 2022).

III. *Requirements Documentation* involves communicating requirements between the stakeholders and the agile team (De Lucia & Qusef, 2010).

IV. *Requirements validation* is the review of requirements specification to ensure that it is documented for the correct representation of software that users expect (Maalem & Zarour, 2016; Laplante & Kassab, 2022). The important question to answer here is "Am I building for the right product" (Laplante & Kassab, 2022).

V. *Requirements Management* is the process of managing the realities change in requirements overtime (Laplante & Kassab, 2022). The integration between RE framework and scrum methodology will be adapted in this study.

Table 2.1: RE in collaboration with scrum methodology (De Lucia & Qusef, 2010)

RE in collaboration with Scrum methodology	
Requirements Engineering activities	Scrum methodology
Requirements Elicitation	Product Owner (PO) provides details of the Product backlog. Any Stakeholders can take part in the Product backlog sessions.
Requirements Analysis	Product Backlog Refinement session. Product Backlog are prioritized by the PO. Requirements feasibility is analysed by the Product owner.
Requirements Documentation	Done with a face-to -face communication with stakeholders.
Requirements Validation	Review sessions on the requirements
Requirements Management	Sprint Planning meetings. Track items in the Product Backlog. Requirements changes are added/deleted to/from the product backlog.

2.2. Related work

Many empirical studies (Clark, Tanner-Smith, & Killingsworth, 2014; Abdul Jabbar & Felicia, 2015; Hamari, Koivisto, & Sarsa, 2014; Martí-Parreño, 2019; Hwang & Chang, 2020) conclude that, GBL can lead to valuable educational outcomes and sometimes they can go beyond the call of duty in a child ‘s life (Mohanty et al., 2021).

Although GBL has been recognised and acknowledged as a successful learning tool to helping learners to improve their learning, it is of importance to consider the types of games used in education and research (Tay et al., 2022). The authors note digital game-based learning (DGBL) tools are to be designed with the intent of teaching. It is also important to consider the benefits of DGBL beyond gains in performance and also consider the effectiveness of the game as teaching tool when considering a game (Tay et al., 2022). Some Researchers chose to use out of the box types of games in their work, instead of developing a DGBL tools that purposefully teach a topic. This results in issues such as relevance and the link between game type and instruction objectives (Nousiainen, 2018; Sanchez et al., 2010). Hence it is important to identify the requirements needed to build such learning tools.

The high variance within the subgroups of education as well as the gaming mechanisms show that gaming mechanisms should be carefully developed to meet the learners ‘s different needs in different educational stages (Tay et al., 2022). It is important to note that different DGBL tools are designed to serve different purposes in the learning process, therefore careful consideration is needed when designing the games (Sanchez et al., 2010). The learning purpose must be considered as a whole to determine which games fits a specific learning environment (Tay et al., 2022). In the most recent study of a design and development of digital game-based learning for school curriculum in rural population, the authors looked at different requirements needed to develop the application: Simple Interface, Accessibility, and thought- provoking (Mohanty et al., 2021).

The meta-analyses on GBL some authors conclude that “the important question is not if but how game-based learning can support learning” (Clark et al., 2016). The authors argued that productive learning can indeed be supported by games, but the design of the game will determine and influence the efficacy of the learning environment (Clark et al., 2016).Another study, an approach as to how GBL should be designed was developed as a result of teachers who still don’t acknowledge GBL as effective tool to be used in classrooms, as most people use the Instructionist approach to have student play educational games, Kafai (2017) suggested adding a constructionist approach to it. Meaning combining the instructionist approach with constructionist approach by having learners design their own learning games than professionals.

According to Bolstad (2018) in his research study on GBL practices in New Zealand, he says the questions which comes into play when researching GBL are: what game design features are particularly good for a specific learning type? As design is important, some researchers have studied how to design the GBL. An Ecological approach is adopted by leading researchers in field to understand GBL (Salen, 2008; Young &

Slota, 2017). Ecological approach defined as a set of relationship that exist between any complex system and their environment and surroundings (Bolstad, 2018).

Another study by Arnab & Clarke (2017) reported that even though there exist scientific and empirical studies that serves as standards for establishing scientific validation regarding the efficacy of using games to help achieve good outcomes, there is a lack of standard framework or standard methodologies to be followed to better guide game-based intervention development .The study furthermore points out that there is a need to relook at the multidisciplinary process and existing knowledge from the relevant disciplines with aim of developing a formal standard of considerations and approaches beyond disciplinary perspectives, this help and serve as a guide to inform the development process of game-based learning (Arnab & Clarke, 2017).

Rooney (2012) suggested that a useful addition to the existing design literatures and framework for GBL will be developing guidelines for integrating relevant components for serious games (GBL). Arnab & Clarke (2017) argued that there is still a lack of tools and methodologies not only from a design perspective but also for analysis and as well as evaluation. The authors argued that there must be some kind of development process or life cycle to be followed or supported from the user requirement perspective to the development, deployment, and evaluation for GBL.

From a design perspective, there is lack of methodologies and tools for design and development of GBL, as according to Bolstad (2018) in his research study on GBL practices in New Zealand, he says the questions which comes into play when researching GBL are: what game design features are particularly good for a specific learning type?

As design is important, some researchers have studied how to design the GBL. An Ecological approach is adopted by leading researchers in field to understand GBL (Salen, 2008; Young & Slota, 2017). Ecological approach defined as a set of relationship that exist between any complex system and their environment and surroundings (Bolstad, 2018).

Although research on GBL has gained popularity in most foreign countries only some kind of online learning currently exists in South Africa, i.e., e-learning platforms which are mostly used in universities, and M-Thuto, which is a mobile learning system that support learners to learn other language which is not their first language (Jantjies & Joy, 2015). The tool is used to learn mathematics using other languages such as Tswana and English. A study was done in SA on techniques to enhance the outcomes GBL in Deaf and Dumb illiterates (Kotnana et al., 2010). Another study proposed the use of offline games to create cyber security awareness for k-12 learners (Kritzinger, 2015).

In another study done in South Africa (SA), experimental research was done to explore the effectiveness of DGBL in improving the academic efficacy among vocational students (Roodt & Ryklief, 2019). The results of this study revealed that motivated students have significant impact on academic achievement, students,

and that academic achievement using DGBL an instructional approach were better than those students learning though the traditional approach.

Furthermore, another study by Mfeka & Thomson (2019) conducted in KwaZulu Natal (KZN) and Western Cape (WC) which was funded by The DG Murray Trust, which was a longitudinal study for the foundation phase for Grade R to Grade 4. The study was conducted over the period of 2014 – 2017, and data was collected and analyzed through 2018/2019. Each school was given an Xbox Kinect and a bank Intel tablets to use in the classrooms to learn. With the goal of improving English literacy in rural schools in SA, the findings of the study were that the Grade 4 learners involved in the project achieved very high-level scores than the control school learners, and not only did they improve in the English literacy, but they also improved in subjects like Mathematics, Natural science & Technology, Social Sciences and Life Skills (Mfeka & Thomson, 2019).

According to Oliver (2018), GBL has not really found its feet in SA as an alternative tool to enhance education. In the article, the author provides an overview of digital game-based learning (DGBL) from a South African perspective and urges South Africans to participate more in digital worldwide shift within education. Oliver (2018) suggests implementing technology-enhanced learning (TEL) and digital game-based learning (DGBL) within theology in universities. The author recommends and encourages that lecturers in South Africa contribute to the research on, and experiment with, as well as implement Technology-enhanced learning (TEL) and Digital Game-Based Learning (DGBL) as part of their curriculum development.

2.3. Summary

This chapter discussed all the areas related to the study through literature review. Theoretical background covered; the definition of GBL and all its components, teachers ‘s perception on GBL, challenges of GBL, learners’ education in south Africa and requirements engineering, scrum method, and how the 2 methods related to each other. Related work discussed the consideration to be made when designing a game, as well as consideration on type of DGBL needed or a particular group of people. Lastly, the chapter touched on GBL in South Africa.

3. CHAPTER THREE: RESEARCH METHODOLODY

This chapter presents a description of the methodological choices made to execute this study. This research methodology chapter is structured based on the research onion model (Saunders et al., 2003), which clearly describes the clear steps followed in this study. A research methodology is the approach in which research is conducted to solve research problems (Mishra and Alok, 2017).

3.1. Research Philosophy

Research philosophy is explained "a system of beliefs and assumptions about the development of knowledge" (Saunders et al., 2019). Philosophical assumptions support the methodological choices of the study, which in turn influences the choice of research design, data collection and analytic techniques to be used in the study (Wahyuni, 2012).

3.1.1. Pragmatism Philosophy

This study is based on the underlying pragmatic paradigm which underlines a suitable research definition which will determine which methods are considered appropriate for this study. Salkind (2010) described a pragmatic research study as an actual real-world situation done by an individual decision maker. The author stated that, when undertaking a pragmatic study, the initial task is to identify the problem and the interpretation of it within its broadest context. This will result in a research inquiry, which seeks to better understand the problem, and eventually how the problem will be solved. Finally, more often, new environmental initiatives, policy suggestions, or social change are the result of the research findings. Pragmatism usually means practicality – doing what works (Rorty,1991). Pragmatism as a philosophy is an approach that describes the value of an idea or believe from it 's practical consequences (Kaushik & Walsh, 2019).

The aim of the study is to identify the requirements needed for web GBL platform for Grade R-12 learners in South Africa using Scrum method. Therefore, it adopts pragmatism research philosophy to identify the requirements needed to develop a GBL Platform that will solve some of the learning problems of Grade R-12 learners in SA.

This will be done by evaluating the learners school environment, their learning techniques, how they are taught, how they learn best, access to the correct learning material, evaluate computer literacy, evaluate their knowledge on GBL. Engaging with learners and teachers on regular basis until the requirements are identified. The nature of interactions with learners and teachers will be determined by access to resources, either online or physical, bottom line doing what works to get the requirements completed. Hence the adoption of pragmatism research philosophy. Thus, the aim of a pragmatist is to find out what work and then provide solutions to the problem at hand (Patton, 1990; Creswell, 2009).

3.2. Research Approach

Choosing the research approach is the second stage in the construction of research methodology. Johnston (2014) explains the term research approach explanation comes from how a researcher undertakes the research activities, the choice of methods the researcher will be using, as this will equally explain why the research is done in that way.

There are 3 type of research approach, namely the Inductive approach, the deductive approach, and the abductive research approach. The study used a deductive approach which involves the evaluation of propositions or hypotheses related to an existing theory using data collection. The theory can be either verified or falsified (Dudovskiy, 2016). This study used deductive reasoning approach because literature already proved that GBL can be used to help aid the learning of Learners(hypothesis) and then from this knowledge, the study has collected data from the stakeholders and analysed the data and then identifies the requirements needed for digital game-based learning platform in township schools.

3.3. Research methodological choice

This study adopted a mixed methods research methodology. The mixed methods approach in methodology enables researchers to answer questions regarding the nature of the phenomenon from a participant's point of view, as well as the relationship between measurable variables in a single study (Williams, 2007). Mixed methods methodology supporters encourage doing 'What seem to work' to investigate, predict, explore, describe, and understand the phenomenon (Mitchell, 2018). Mixed methods methodology, to answer research question(s), the researchers collect or analysis not only numerical data for quantitative research, but also narrative data for qualitative research (Williams, 2007). This approach is not a replacement for quantitative and qualitative approaches rather an extension to the approaches (Johnson & Onwuegbuzie, 2004).

A survey was used to collect data for this study, which included paper-based questionnaires. Some questionnaires were sent via email to the teachers, while most were printed and handed out physically to the learners and teachers by the researcher; this was quantitative data. Data was also collected through document review specially to understand the aspects of game-based and scrum requirements framework, which was mostly qualitative data. Lastly, quantitative data was collected during the evaluation of the requirements by the requirements analysts.

3.4. Research Strategy

A research strategy is a process that involves a number of steps that sets the direction of research (Malhotra, 2017). It is the plan for a particular study which provides the overall structure for collecting data (Sileyew, 2019). The research strategy is a subset of research design, it involves data collection elements and interpretation and begins from both research purpose and question (Malhotra, 2017).

3.4.1. Design Science Research

The design science research (DSR) is a problem-solving practice that create innovative artifacts that seeks to enhance human knowledge. The results of DSR are new designed artifacts, as well as design knowledge (DK) which provides a full understanding of why the need for new artifacts or knowledge enhancement (Brocke, Hevner & Maedche, 2020). For this study requirements are identified, which will be used to build a digital game-based learning platform. The study, therefore, adapts DSR as a research strategy. The different phases of DSR used in the study.

i. **Phase 1: Awareness of the problem:**
   - This entails gathering necessary information about the problem to be solved for the purpose of thorough understanding.

ii. **Phase 2: Suggestions:**
   - Information gathered in phase 1 is analysed and a tentative/proposal design will be created.

iii. **Phase 3: Development:**
   - This entails the development and implementation of the actual artefact.
   - This phase will be iterative process, until the development of artefact is completed.

iv. **Phase 4: Evaluation:**
   - Testing of the artefact to ensure and validate the purpose for which it was created for.

v. **Phase 5: Conclusion:**
   - This is the final phase of DSR. Research results and Contribution are identified.

3.5. Research Design

The research design for this study is based on the DSR strategy is outlined as follows:

3.5.1. Awareness of the problem: Requirements Elicitation (Phase 1)

This is the first phase of DSR which involved data collection for the purpose of requirements elicitation. Data was collected by interacting with the stakeholders from various schools. The stakeholders are various teachers, learners from township schools. This is to gain preliminary understanding of the educational domain to understand issues around student learning. The focus was on learners in the foundation, intermediate and senior stages, and their teachers. No specific type of learners was be targeted. All learners that agree to participate were allowed to take part of the study. This is to enable the researcher to gain a

better understanding of the type/form of Game-based learning platforms that is suitable for these group of Learners.

Five schools (2 primary schools and 3 secondary schools) in the townships of Western Cape province participated in the study. The student' ages were in the range of 8 - 17yrs, while 10 - 50 learners were involved per school. As well as 5- 10 teachers took part in the survey. Because the study involved Scrum sessions, 10 – 50 learners were considered to be able to manage the interaction between groups. In each school, stratified sampling (Parsons, 2014) was applied to ensure sufficient representation of the different learner categories to participate in the study.

The survey method was used to engage with the stakeholders. Face-to-face interviews were conducted to gain an in-depth understanding of the key issues around student learning. Document reviews was used to find information about the different kinds of GBL and gamification that already exist.

3.5.2. Suggestions: Design of the Scrum-based RE Framework for GBL (Phase 2)

Based on the information gathered from phase 1, scrum activities were used – such as product backlog and user stories to analyse the data. Document review was used to guide the design of scrum-based requirements engineering (RE) framework for web GBL (Batool et al., 2013). The RE framework will engage the principles of scrum methodology to identify the requirements for a game-based learning (GBL) web platform.

3.5.3. Development: Application of the Scrum-based RE framework for GBL (Phase 3)

This phase involved the implementation of the proposed Scrum-based RE framework based on the process defined in Phase 2. The development phase was an iterative process until all the activities of the RE framework were completed. This includes engagement with relevant stakeholders, the use of appropriate requirements engineering tools and techniques. The Scrum-based RE framework was implemented to identify the requirements needed to build a GBL web platform.

3.5.4. Evaluation: Evaluation of Requirements Quality (Phase 4)

In this phase, the requirements that are generated by applying the RE framework for GBL were presented to Requirements Analyst and Game Developers for evaluation. Evaluation of the requirements is in a form of rating, where the respondents have rated the requirements according to particular attributes. The mean rating of experts was used to determine the quality of requirements based on standard requirements quality metrics. The study used combination of the Weiger's Quality model (Wiegers, 2003); and Pohl's quality model (Pohl,2010) for the evaluation of the requirements.

Weiger's Quality model (2003) and Pohl's quality model (Pohl,2010) propose two sets of characteristics, one applicable to individual requirements and the other to the whole requirements document. They both share the same requirements qualities relative to individual requirements (Complete, Correct, Feasible, Necessary, Prioritized, Unambiguous, Verifiable) and as a set of requirements that refers to the entire document (Complete, Consistent, Modifiable, Traceable). However, Weiger's model does not define Atomic

and Non-Redundant quality attributes on individual requirements, While Pohl's model has those quality attributes and more (Rated, Up to Date and Atomic). Furthermore, Pohl's model has added one more attribute to the requirements as a set (Readability).

3.5.5. Conclusion: Derivation of study conclusion from findings (Phase 5)

This the last phase where the findings from the evaluation by experts in the field were used to derive the conclusion of the study. The steps of the adopted research design for this study are shown in figure 3.1. while the mapping of the methodology to objectives of the study is shown in Table 3.2.

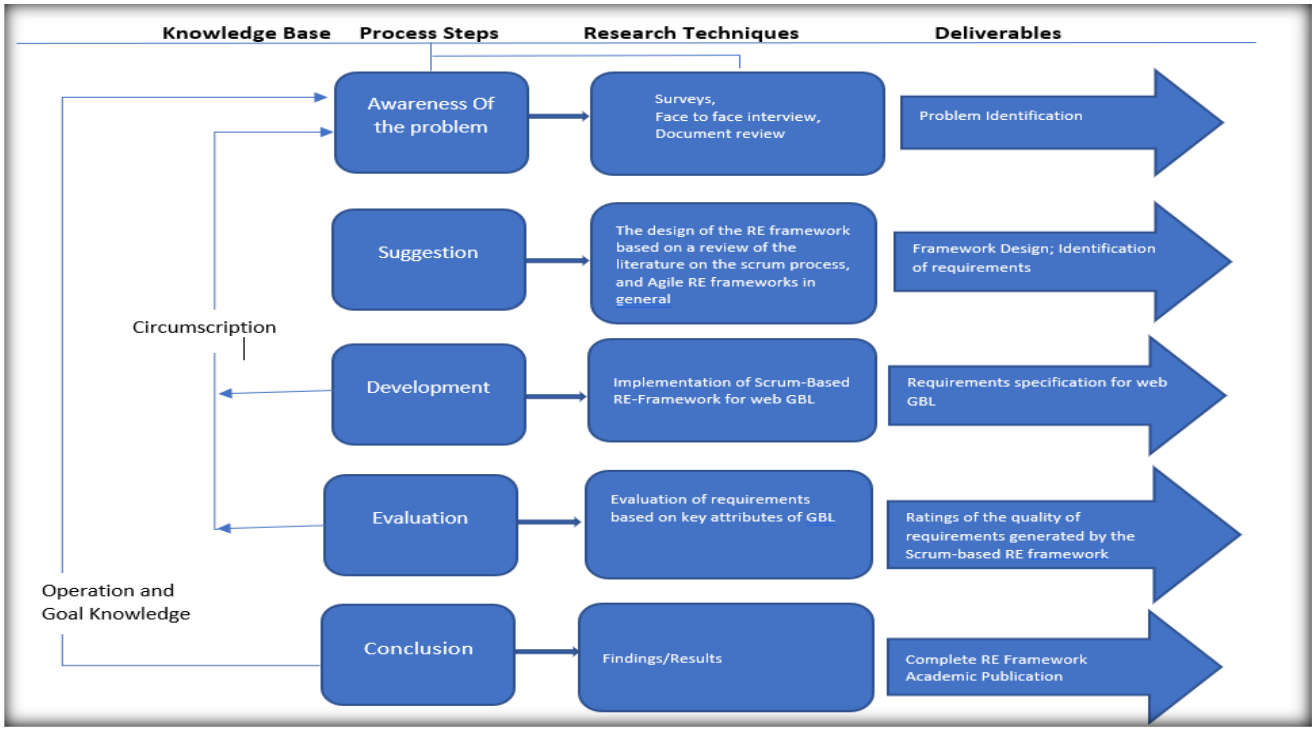

Figure 3. 1: Steps of the adopted research design for the study (Vaishnavi & Keuchler, 2004)

Table 3.2 Mappings of the objectives, phases of DSR, the methods and output.

Objectives	Phase of research design	Methods/Techniques	Output
To determine the type and mode of GBL that is relevant to Grade R- 12 Students in South Africa	Phase 1	Surveys, Face to face interviews, Document/product review, Prototyping	Problem identification
To design a RE-Framework for GBL web platform based on Scrum	Phase 2	Design of the RE framework was based on review of the literature on scrum process, and Agile RE frameworks in general.	Framework Design; Customized RE process lifecycle

To demonstrate how the scrum-Based RE framework can be used for specification on requirements for a GBL web platform for Grade R- 12	Phase 3	Implementation of Scrum-Based RE-Framework	Requirements specification for web GBL
To Evaluate the quality of requirements obtained through the application of scrum- based RE Framework	Phase 4	Evaluation experiment	Ratings of the quality of requirements generated by the Scrum-based RE framework

3.6. Ethical Considerations

There are various ethical considerations that needs to be followed when doing a research study (Silverman, 2017). The Researcher should remember that they are entering the private space of their participants, which raises several ethical issues that should be addressed during and after the research has been conducted. The study will adhere to the following ethical considerations.

i. Informed Consent:
   - The researcher asked for authority from the Western Cape Department to undertake this research in schools.
   - The researcher also asked for permission from schools before conducting the surveys and clearly informed the respondents (Teachers, Parents and Learners) about the purpose of the study.
   - The consent of relevant stakeholders such as teachers and learners, whose kids are in foundation and intermediate stages were obtained. No specific type of learners were targeted. All learners that agree to participate were allowed to be part of the study. The questions asked were not focusing on finding weakness in all areas, and not on specific subjects so that no learner will feel stigmatised.

ii. Data Privacy and Confidentiality
   - The researcher guaranteed the respondents that their personal details and the institution they work for, will be kept confidential and there is no hidden agenda behind the study.

iii. Data security
   - The researcher stored data from the survey conducted in a safe and secure area.
   - Data is accessed via encrypted password.

3.7. Summary

In this chapter the methodology used in the study was discussed in detail, which contributes a lot to the objectives of the study. It elaborated in detail how the different phases of DSR were implemented to achieve the objectives of the study.

4. CHAPTER FOUR: ELICITATION, ANALYSIS AND PRIORITIZATION OF REQUIREMENTS

In this section, the phases of DSR approach will be used to explain the process of requirements engineering. The chapter will elaborate how requirements elicitation, requirements analysis, requirements prioritization and generation of requirements was done.

4.1. Requirements Elicitation

Requirements elicitation corresponds to the first phase of the adopted DSR strategy. Requirements elicitation was done by distributing questionnaires to township schools. Two schools (Primary and Secondary) in Khayelitsha, another two in Mfuleng (Primary and Secondary) and one secondary school in Kraaifontein. Online and face to face surveys were used. In some schools, the questionnaires were emailed to the principal and printed out at the schools and then copies of the questionnaires were distributed to the learners and teachers by the school secretary. In most instances, the researcher printed out the questionnaires and physically distributed them to the schools. During physical distribution of the questionnaires, the researcher was available for any questions should the participants have any regarding any item in the questionnaires. Data was also collected by interacting with the stakeholders from these schools.

The age of the learners is between 8 - 17yrs. About 20-50 learners per school took part in the survey, and 5-10 teachers per school. Simple random sampling used to select the participants. The profile of the participants in the surveys is presented in Table. 4.1.

Table 4.1: Description of participants

School Names	Role	Total Participation	
		Selected	Responded
Group A	Teachers in Primary School	10	5
	Learners in Primary School	50	50
Group B	Teachers in Primary School	10	5
	Learners in Primary School	50	44
Group C	Teachers in High School	10	10
	Learners in High School	50	50
Group D	Teachers in High School	10	10

	Learners in High School	50	50
Group E	Teachers in High School	10	7
	Learners in High School	50	50
Total Respondents			281
Total of learners' participation			244
Total of teachers' participation			37

The data collected from the survey was stored in MS Excel to enable data analysis. To satisfy the first objective of the study, which is to determine the type and mode of GBL that is relevant to Grade R-12 students in South Africa. The information that pertains to learners that were extracted are as follows:

i) The personality of the learners
ii) Learning style of the learners
iii) The type of digital resources available to the learners
iv) The level of computer literacy of the learners
v) Disposition of learners to game playing
vi) Frequency of playing games by learners
vii) The type of devices used to play games.
viii) Type of games preferred by the learners.
ix) Aspects of a game liked by the learners.
x) Elements of a game liked by the learners.

Information that pertains to teachers that were extracted are as follows:

i) Teaching styles of the teachers.
ii) Teachers 's classroom challenges.
iii) Class motivation techniques used by teachers.
iv) Teachers' computer literacy.
v) Frequency of playing games by teachers
vi) Game play competency by teachers
vii) The type of devices used to play games.
viii) Type of games preferred by teachers.
ix) Aspects of a game liked by teachers.
x) Elements of a game liked by the learners.
xi) Awareness of Gamed-based learning platform by teachers

The questionnaire used for the survey is available in Appendix C.

4.1.1. Analysis of survey results

Descriptive statistics analysis was used to analyse the collected data. This was done using frequency count and percentage score. Responses were received from 244 learners. One learner who agreed to participate in the study did not submit the questionnaire. Thus, there was a 99.5% response rate among the learners. For teachers, 37 responses were received.

The results obtained from analyzing various aspects covered by questionnaire are presented in Table 4.2. The aspects covered include the different personality types and preferred learning styles of learners based on their responses. Almost half of the learners described themselves as friendly (50%), and many learners acknowledged that they were talkative (30%). In contrast, some others described themselves as shy (19.26%), quiet (13,93%) and thoughtful (11.47%), respectively. Also, more than half of the sampled learners (52.87%) described themselves as verbal learners that prefer to learn by reading or listening. A significant few see themselves as social learners (25.4%) that love to learn through social interactions while working in groups and teams. Some prefer working alone and self-study (18.44%). A few learners also describe themselves as visual (13.93%), kinaesthetic, logical, and aural learners.

Table 4.2. Personality and Learning Styles

Personality	**Percentage**
Action-oriented	4.09 %
Outgoing	8.19 %
Reserved	7.78 %
Social	9.42%
Thoughtful	11.47 %
Quiet	13.93 %
Shy	19.26 %
Talkative	29.5 %
Friendly	50 %
Learning Styles	**Percentage**
Aural	6.96 %
Logical	7.78 %
Kinaesthetic	6.96 %
Visual	13.93 %
Solitary	20.72 %
Social	25.4 %
Verbal	52.87 %

It is important to note the teaching styles from the teachers as they also play a role in determining what kind of games will the learners need. As already said in literature review, teacher's input is very important in the adoption of GPL in the classrooms (Huizenga et al., 2017). Most teachers indicated they use demonstration style (59.45%) to teach and while others use Facilitator style (37.38%) to teach. Data analysis also indicated that some teachers use Delegator style (29.72), while a small group uses Hybrid (16.21%) and Authority (13.51%) style.

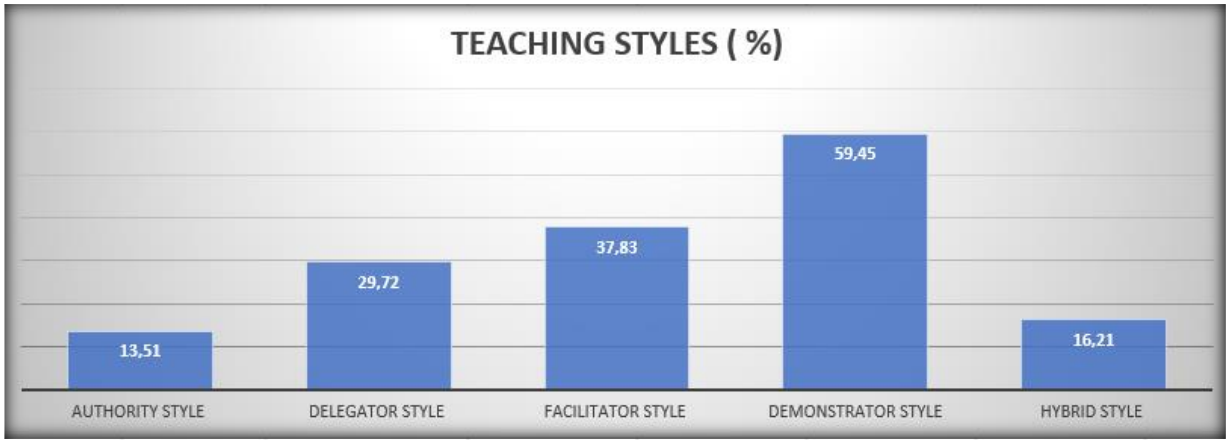

Figure 1.1: Teaching Styles

It is also important note weather or not learners and teachers have access to facilities that will allow them to start utilizing GBL platforms. Figure 4.2 - captures the type of access to digital resources that the learners have, while Figure 4.3 shows how any teachers have access to computers at school (89.18%) and home (83.78%). Therefore, making positive results because it then indicates that teachers have access to the resources needed to offer lessons in a digital environment.

The result indicates that most learners do not have access to computers at school (61.88%) and at home (64.34%). However, more learners have access to cell phones at home (72.95%) than at school (22,13). In addition, few learners did not respond to the questions about access to digital resources.

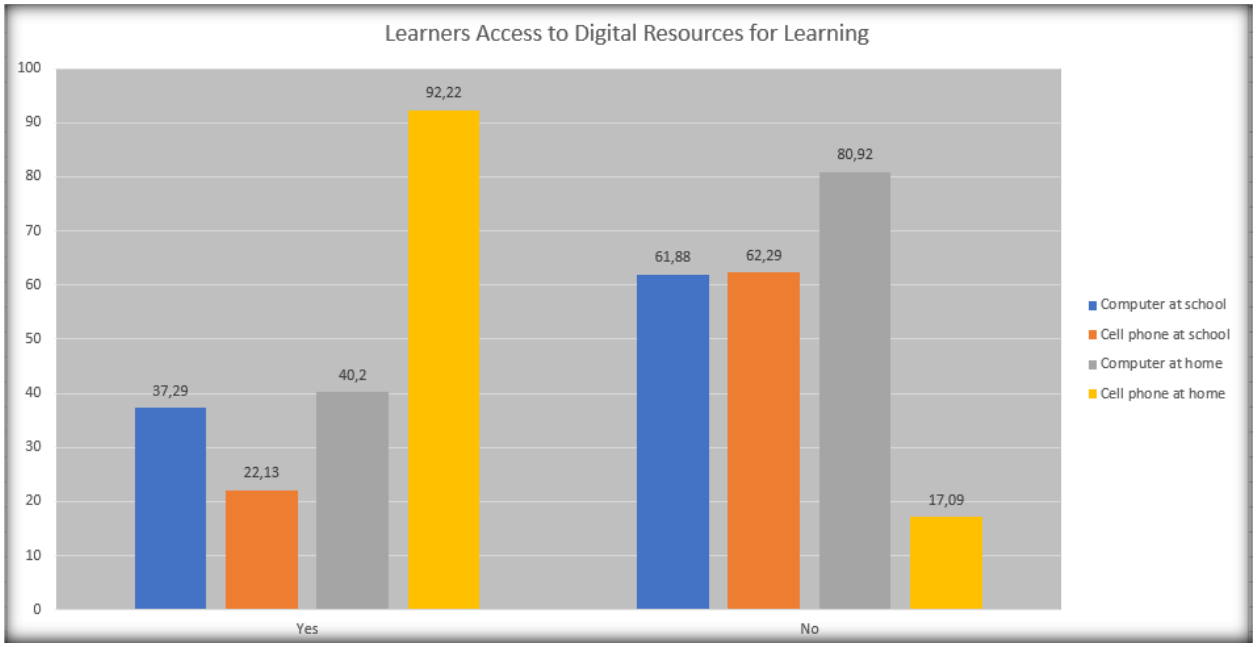

Figure 4.2: Learner's access to digital resources

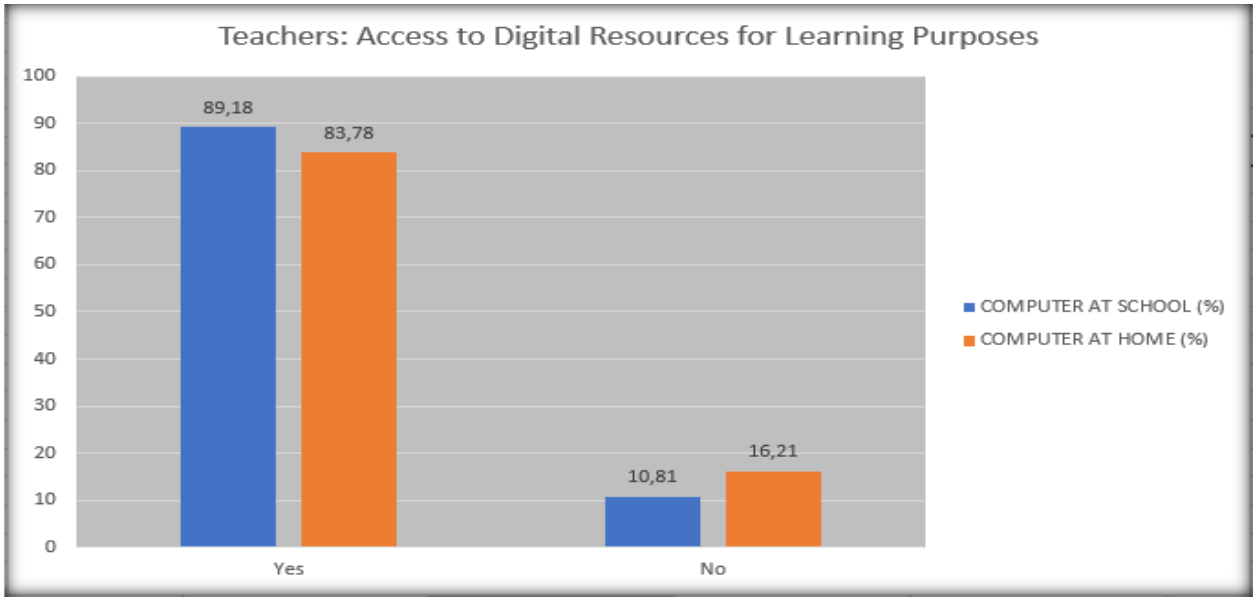

Figure 4.3: teachers' access to digital resources

The disposition of learners to game playing, the results show as per the chart in figure 4.4 that, the learners that play computer games (76.63%) are significantly more than those that do not play computer games (22.13%). Teachers game play was also taken into consideration and analysis showed that more than half of the teachers do play games (56.75%). Therefore, it becomes a positive result as a lot of these learners will adopt to GBL learning platforms easily.

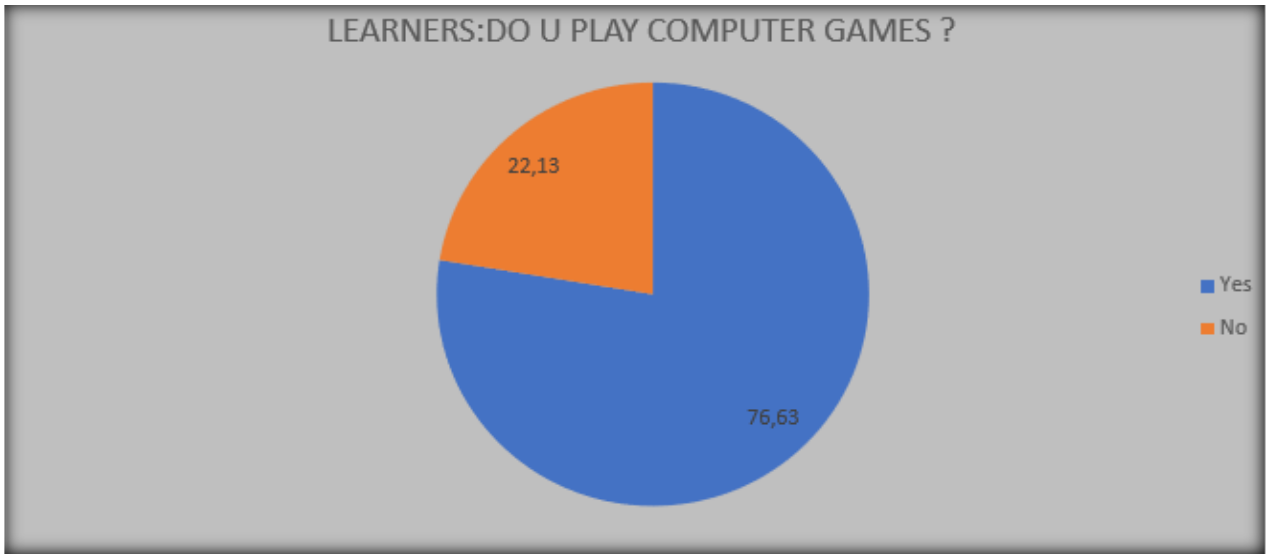

Figure 4.4: Disposition of Learners to Game playing

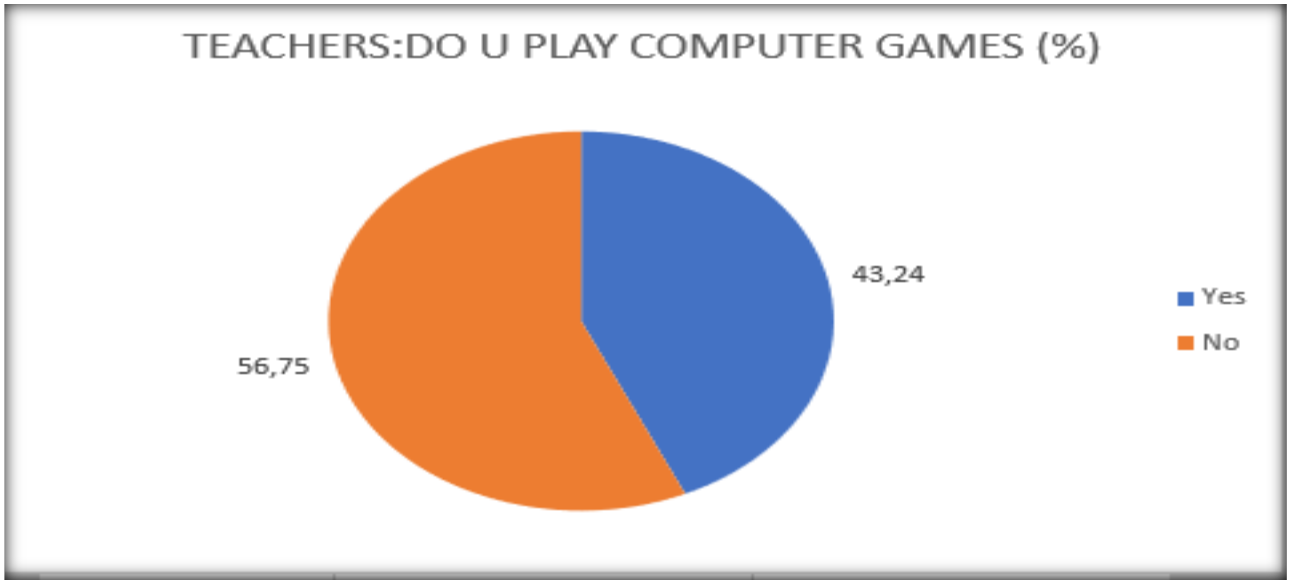

Figure 4.5: Disposition of Teachers to Game playing

Table 4.3 - shows how frequently the learners play games and the types of devices used to play games. 21.31% of the learners claim to play games almost every day, while others play games once or twice a month (29.5%), and a small number of learners play games once a week (21.31%). The result also showed that most learners use smartphones to play games, which makes sense because most of these learners have already indicated that they have access to cellphones at home (See Figure 4.2).

Table 4.3: Frequency of Playing Games and Devices Used

How often do you play	**Percentage**
Once a week	29.5%
Once or twice a month	29.09%
Almost Every day	21.31%
Devices used to play	**Percentage**
Video game devices	3.68 %
Computer tablet	6.14%
Computer	66.55 %
Console - PlayStation	16.14 %
Smartphones	72.95 %

Table 4.4 - shows the preference of learners in terms of the type of games they like, the specific aspects of a game that they like, and the elements of a game that they find interesting. More learners indicated that they like puzzles (33.6%) and video games (25%). At the same time, some learners showed that they liked word games (25.4%), simulation games (14.34 %) and card games (12.29%), while a small group liked board games (8.19%) and role-playing games (10.2%).

In addition, most learners like aspects of a game that involves rewards in the form of visual aesthetics (35.65%) and musical scores (33.37%), while some like aspects of the incentive systems (27.45%) and the

game narrative (23.77%). A small group of learners indicated that they like the game mechanics aspect (8.8%).

In terms of key elements of a game, learners indicated to like challenging games (60.24%), as well as games that enable competition with others (26.63%) and trigger curiosity games (20.9%). Fewer learners liked collaborative (13.93%) and fantasy games (13.7%).

The analysis also showed that 82.37% of the learners believe that playing games can help them learn better, while 83.41% think that playing games can help them learn subjects they perceive as difficult. Some of the learners listed Mathematics, Pure Science, Commercial subjects (Accounting), Mathematical Literacy, and Geography as difficult subjects.

Table 4.4: Game Preferences of Learners

Type of games	**Percentage**
Board games	8.19 %
Role-playing	10.2 %
Card games	12.29%
Simulation	14.34 %
Word games	25.4 %
Video games	25%
Puzzles	33.6 %
Aspects of the game	**Percentage**
Game mechanics	8.19%
Narrative	23.77 %
Incentive systems	27.45 %
Musical score	33.37 %
Visual aesthetics	35.65 %
Elements of the game	**Percentage**
Fantasy	13.7 %
Collaborative	13.93 %
Curiosity	20.9%
Competing with others	26.63 %
Challenge	60.24 %

4.1.2. Survey Results

Based on the results obtained from the survey, a summary of the findings as it relates to the personality types of learners, access to digital resources, the disposition and frequency of playing games, the type of games liked by learners and the attributes that they find interesting. The school subjects that the learners find difficult and the implication of these difficult subjects and the adoption of digital GBL in South Africa.

i. Personality of learners: Since most learners describe themselves as either friendly or talkative or both (see Table 4.2), game-based learning platforms that can stimulate social interaction such as multiplayer games for learning. There is a significant number of learners (one third of the percentage of learners) that believe that they are quiet or shy.

ii. Learning style of learners: The results show that verbal learning is the most preferred form of learning among the learners (1 out 2 learners), while social learning (1 out of 5 learners), solitary learning (1 out of 5), and visual learning (approximately 1 out 8 learners) are moderately preferred (see Table 4.2**)**.

iii. Teaching style for Educators: Most teachers indicated that they use Demonstrator style and Delegator style (see figure 4.1). Demonstrator style does not rely on verbal classroom teaching, instead it combines lectures while using other teaching forms, such as the use of multimedia presentations, practical demonstrations, as well as class activities. While Delegator style is learning in a form of group work, learners 's discussion on educational topics to achieve results, while the teacher takes the observer role (Sarode,2018).

iv. Digital game resources, disposition to games, and frequency of playing games among learners: More learners have access to digital resources at home than at school. Many schools have computers, but the ratio of available PCs to learners is high, which means that the computer systems in schools cannot be sufficient to support learners' quest to play games. The majority of the learners play games almost every day. Some play games once a week or more than once a month (see Table 4.3). Learners do not have access to use cell phones while in school, but they have access to cell phones and smartphones at home. The smartphone penetration in South Africa is over 80%, the highest in Africa (Gilbert, 2019).

v. Types of games and aspects and elements of games that learners like: Most learners like puzzles and video games, while word games, simulation games, and card games are also fairly popular, game designers need to invest more effort in developing game platforms that possess these characteristics (see Table 4.4). Features such as visual aesthetics and musical scores rank high on the scale of preferred game requirements from the learners' perspectives. Games that demand solving a challenge and facilitate competition among multiple players are attractive to most learners.

vi. **Game-based learning and difficult subjects:** Most learners find it difficult to learn Mathematics, Mathematical Literacy, Pure Science, Commercial subjects (such as Accounting), and Geography. Considering that very few learners indicated a preference for a logical learning style, many learners experience difficulty in learning subjects that require calculations.

4.2. Design of the Scrum-based RE Framework for GBL

The design of a Scrum-based framework constitutes Phase 2 (Suggestion) of the adopted DSR strategy. In this phase, a RE- framework for GBL web platform based on Scrum for grade R–12 learners in South Africa was designed. This section explains the different activities that were done throughout the study to achieve this.

4.2.1. Scrum- based Requirement Engineering Process workflow.

The formulation of the RE framework was based on facts extracted from the literature on Scrum methodology (Batool et al., 2013), agile requirements engineering (De Lucia & Qusef, 2010), and game-based learning (Dimitra et al., 2020; Mohanty et al., 2021).Figure 4.6 shows a proposed scrum RE process flow that specifies the entire process that should be was followed to identify the requirements for web-based GBL platform for Grade R-12 in South Africa.

The activities of the process workflow for the Scrum-based RE for GBL for R-12 learners are presented as follows:

i) Requirements Elicitation:
- ✓ The product owner in this case, the Researcher, will present the vision to the stakeholders (different schools) – which is the research proposal, ethics document and other related document.
- ✓ Product owner will send out survey to the different schools to be completed by learners and teachers. The survey will be sent out either via email or in person to the schools.
- ✓ After receiving feedback from schools, the results of the survey will be stored in MS excel spreadsheet.

ii) Requirements Analysis:
- ✓ This is where themes will be extracted from the stored excel data.
- ✓ Results will then be established from the themes – which will result in findings report. From this report, the type and mode of GBL for this particular schools will be identified, as well as the features will be identified.
- ✓ Features will then lead to formulation of users' stories.
- ✓ The Users stories will be presented to the stakeholders in schools for verification. For each interaction the product owners will make amendments to the requirements specification document.
- ✓ After the stakeholders verify the identified user stories, the user stories will then be prioritised.
- ✓ Thereafter, a requirements specification will be documented with requirements needed to develop a game-based learning web platform.
- ✓ Requirements will be grouped into functional and non-functional requirements.

iii) Requirements Validation:
- ✓ This is where the grouped requirements will be presented to the group of experts for rating.
- ✓ The requirements will be rated by a group of experts in the field of requirements analysis.
- ✓ Group of experts are the Business Analyst (BA), System Analyst (SA), Analyst Developer and Software Developers.

iv) Requirements Management:
- ✓ Once response is received from a group of experts, the Product owner will have to amend and make changes to the requirements based on experts' comments.

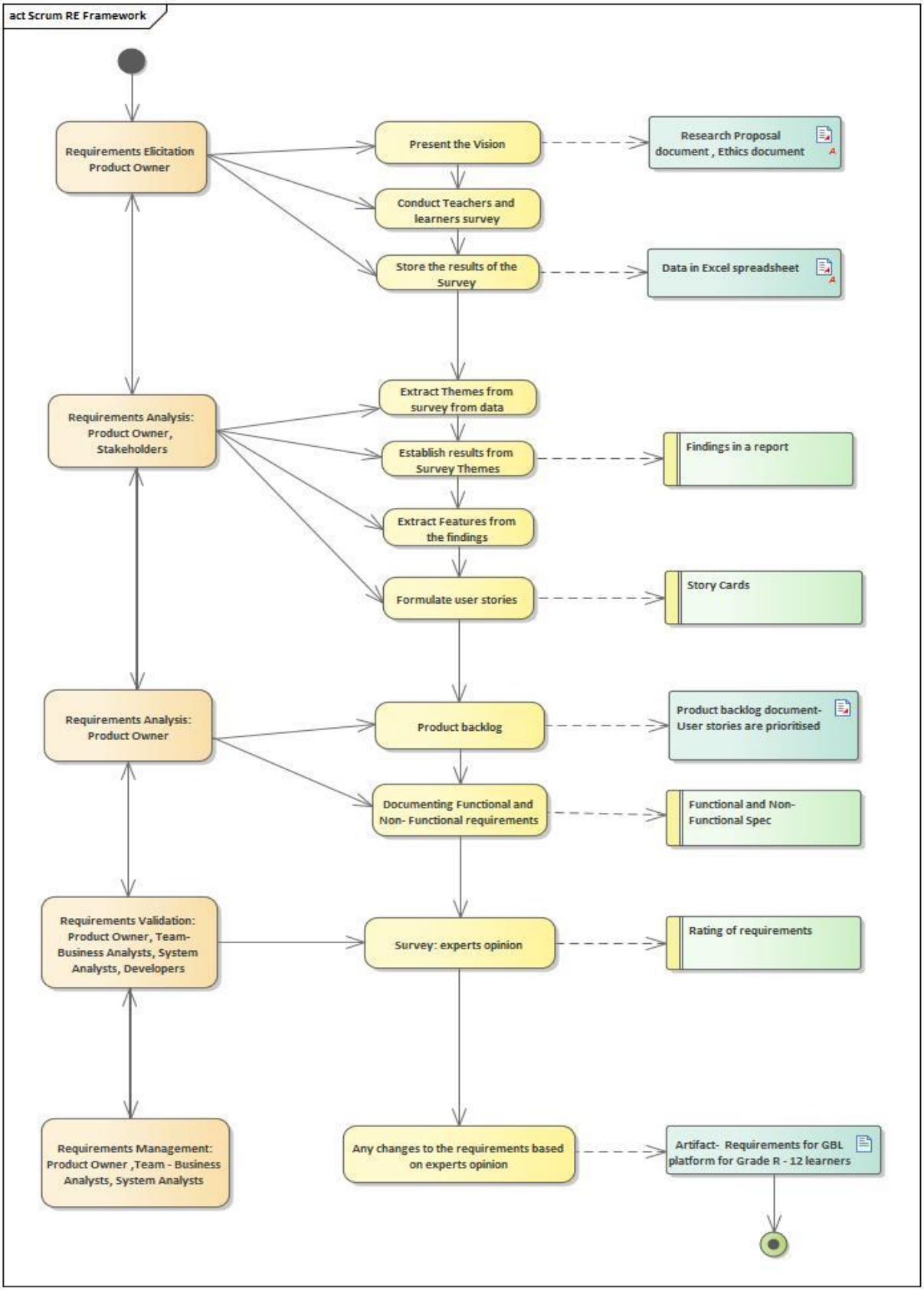

Figure 4.6: Scrum RE Framework adopted.

Table 4.5 shows the Scrum-based framework to identify the requirements for a game-based learning platform. It defines the RE process that should be followed while using scrum to identify the requirements needed to build a game-based learning system.

Table 4.5: A framework for Scrum based Requirements Engineering

	RE in collaboration with Scrum methodology	
Requirements Engineering activities	Activities	Scrum methodology
Requirements Elicitation	• Conducting of Survey on game-based learning for Grade R -12 in SA schools. • Data from the survey to be stored in Excel. • Themes to be extracted based on the data from the survey. • Establish results from the themes report. • Document the results to formulate Features.	Product Owner (PO) provides details of the Product backlog. Any Stakeholders can take part in the Product backlog sessions.
Requirements Analysis	• Interactive session with the stakeholders (Teachers and Learners) ❖ Formulation of user stories from the features of GBL platforms. ❖ Presenting the user stories to the stakeholders through scrum sessions. ❖ Stake-holder's prioritization based on user stories gathered through Scrum sessions.	Product Backlog Refinement session. Product Backlog are prioritized by the PO. Requirements feasibility is analysed by the PO.

Requirements Documentation	• Documentation of the requirements ❖ Functional requirements document ❖ Non-functional requirements document	Documents sent to the stakeholders for review via email. Consent/feedback of stakeholders received
Requirements Validation	• Validation of the requirements quality • A document to rate the requirements was distributed to System Analyst and Business Analyst for review.	Rating of quality of requirements by experts in the field. Business Analyst, System analysts, Analyst developer and software developers.
Requirements Management	• Requirements Management	Sprint Planning meetings. Track items in the Product Backlog. Requirements changes are added/deleted to/from the product backlog.

4.3. Application of the Scrum-based RE framework for GBL.

In this phase, the scrum-based framework that was formulated in phase 2 was applied to identify the requirements needed to build GBL for township schools, which corresponds to the development phase of the adopted DSR strategy (Phase 3). The activities of this phase were conducted iteratively until the requirements were identified and prioritized. This means that certain activities were revisited to refine, analyse, and verify the data to get to the desired results.

4.3.1. User stories Formulation

Based on the outcome of the survey activities in phase 1, the researcher playing the role of product owner in Scrum, formulated the initial set of user stories which were presented to learners and teachers for review in multiple scrum sessions. During this period, the requirements associated with individual user stories were also prioritized. Requirements prioritization is one of the most important techniques in the RE process.

Requirements prioritization is used to list, define and schedule how requirements will be executed based on their priority and importance with respect to stakeholder's point of view (Hudaib et al., 2018).

4.3.2. Requirements Prioritization

The MoSCoW prioritization technique was used for the prioritization of the requirements. MoSCoW technique is considered one of the most straight forward methods for requirement prioritization (Hudaib et al., 2018). The technique is mostly used by analyst and stakeholders to prioritize requirements collaboratively. MoSCoW prioritization technique which begins from the dynamic software development method (DSDM), (Hatton,2007; Tudur & Walter, 2006). As per MoSCoW technique, a list of requirements can be classified into the following four prioritization categories (Tudur & Walter, 2006).

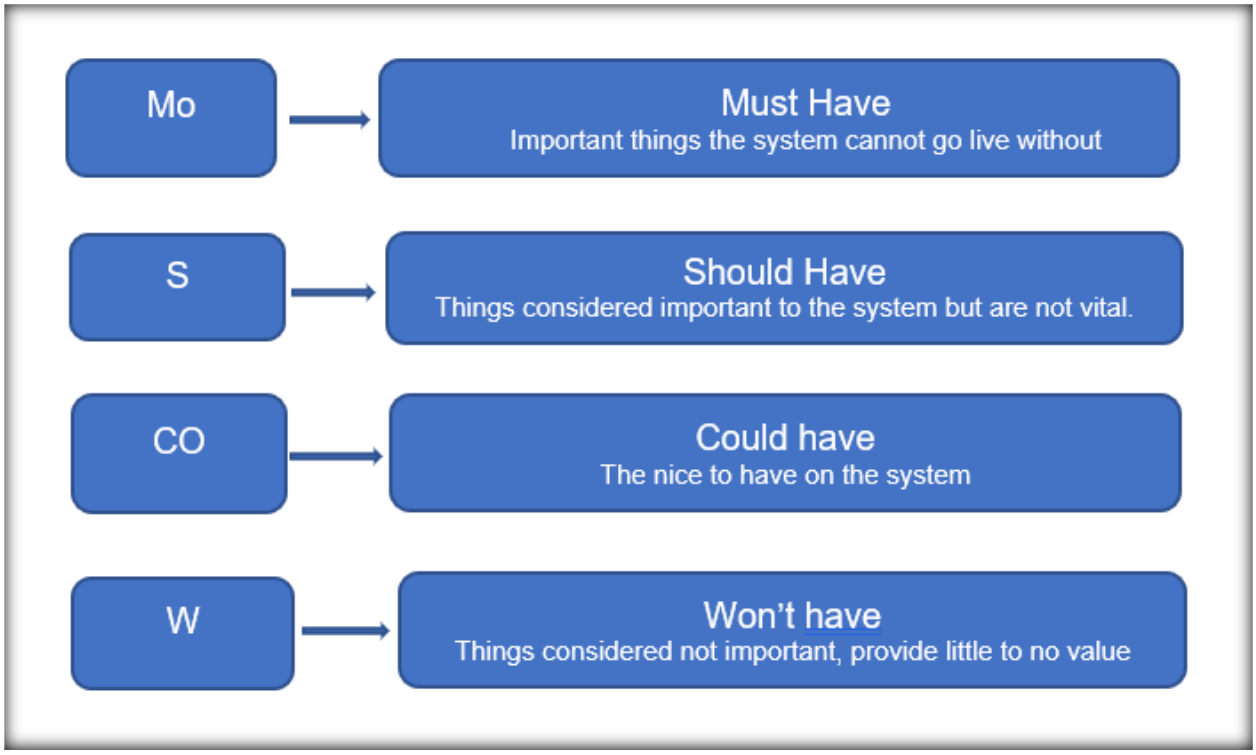

Figure 4.7: MoSCoW technigues – Four prioritization categories, adopted from (Tudur & Walter, 2006)

Scrum sessions were scheduled with school learners and their teachers. The sessions were separate, one session was for learners only and there was a session for teachers only. Learners and teachers from 3 schools took part in the scrum sessions. A total of 8 scrum sessions was done within 2 months. User stories which were formulated based on the results of the survey and were presented to the Scrum Team. Teachers', principals, and learners are the stakeholders in this case, Product owners is the researcher. Table 4.6 to Table 4.8, show the list of user stories presented to the scrum team and samples of the responses obtained.

Table 4.6: Scrum sessions- with learners (Sprint planning, weekly stand-ups, and sprint review)

Prioritization of User Stories by Learners (Functional Aspects) using MoSCoW							
S/N	Themes	Features	User stories	Must have (M)	Should Have (S)	Could have (C)	Will not have (W)
1	**Learners 's Personality**	Support Multiplayer gaming environment	As Learner I want to play digital educational games with my fellow learners, so that we can collaborate with each other.	Yes			
		Support single player gaming	As a Learner, I want to play digital educational games alone, so that I can learn more in solitary			Yes	
2	**Learner's school motivation**	Support for learners-teachers collaboration amongst users	As a Learner, I want to play digital educational games with other learners and teachers, so that I can learn more while engaging with others	Yes			
		Support gaming mechanics to provide feedback to the users	As a Learner, I want to receive feedback from GBL platform in form of results or musical scores, so that I know my progression		Yes		
3	**Learning Styles**	Support graceful failure and desire to learn more	As a Learner, I want to have fun while playing educational games, so that if I don't get the correct results when playing, I will want to happily repeat the task at hand to learn more.	Yes			
4	**Learners difficult Subjects**	Promote logical thinking and reasoning	As a Learner, I want to do calculations in a form of educational games, so that I can stimulate my logical thinking.	Yes			
		Promote problem solving skills	As a Learner, I want to solve mathematical problems while playing educational games, so that I can stimulate my logical thinking.	Yes			
5	**Learners' access to**	Digital games – support all electronic devices – laptops and smart phones	As a Learner, I want to be able to access GBL platform on all digital platforms, such a web and smart	Yes			

	electronic resources		phones, so that can play educational games.				
6	**Do play electronic games?**	Support gaming stages(levels)	As Learner, I want to have an option to choose the different levels of games, so that I can test my knowledge of how good I am.		Yes		
7	**How often do you play computer games?**	Support gaming level for beginners and intermediate	As a Learner, I want to have an option to progress to different stages of the level of the game, so I can see my progression.			Yes	
8	**Devices used to play games**	Supporting gaming that will run on smart phones	As a Learner, I want have access to GBL on smart phones, so that I can be able to access learning material at any given point in time.	Yes			
9	**Game play competency**	Must support different level of difficulty that are interconnected	As a Learner, I want to be able to select one level of the game, so that I can progress to another level		Yes		
10	**Type of games preferred**	Type of games required for learning puzzles and word games, as well as simulation games	As a Learner, I want to play the educational games in a form of Puzzles or Word games, so that I can learn more on a particular subject		Yes		
11	**Aspects of the game liked**	Support design features such as visual aesthetics	As a Learner, I want to have access to a GBL platform that looks colourful, attractive, and easy to play, so that I get motivated to want to play the educational games.	Yes			
		Support musical score sounds aspect.	As a Learner, I want to hear music score sounds as I play the game, so that I can have fun while playing the game.	Yes			
		Support Incentive system	As a Learner, I want to play educational game that offers rewards, so that I can get inspired to do my best while playing the game.	Yes			

12	**Elements of the game liked. e.g., challenge, curiosity, fantasy, collaboratives**	Support gaming that is challenging yet can allow learners to work as group while competing with one another.	As a group of Learners, we want to play educational game that is of challenge, so that the game play is more interesting.	Yes			
		Support learners to answer questions based on a particular subject in a pop-up dialogs and get evaluated by the system	As a learner, I want to be able to learn and answer questions on GBL platform, so that I can see my results.	Yes			
14	**Can GBL help in learning? Do learners and teachers know about GBL**	Support educational outcomes where results of each subject are displayed at the end of the game.	As a Learner, I want to be able to so see the results of school subjects I was tested on GBL, so that I can see my progression	Yes			
15	**GBL can help in difficult subjects**	Support problem solving games and making it fun to learn	As a Learner, I want to play educational problem-solving games while having fun, so that I can grow to love the school subject I am learning.	Yes			
		Should be designed in way that ensures that learners repeat the gaming cycle without being bored or demoralized	As a Learner, I want to access to learning platform that is challenging and engaging, so that I can want to learn more or repeat the learning if needs be.	Yes			

Table 4.7: Scrum sessions – with teachers (Sprint planning, weekly stand-ups, and sprint review)

Prioritization of User Stories by Teachers (Functional Aspects) using MoSCoW							
S/N	Themes	Features	User stories	Must have (M)	Should have (S)	Could have (C)	Will not have (W)
1	**Teaching Styles**	Support for learners-teachers collaboration amongst users	As a teacher, I want a learning platform that will provide collaboration between me and my learners, so that the learners do better in class.	Yes			
2	**Teachers' classroom challenges**	Support gaming that is interesting and encourage to play more and keep on guessing.	As a teacher, I want to play the game that is interesting and challenging, so that it will help me encourage my learners to want to learn more	Yes			
		Support competing games – where learners compete to get the best results	As a teacher, I want to be able to teach in groups using gaming, so that the learners can compete with each other.	Yes			
		Support graceful failure – where learners are encouraged to learn more after failure some certain questions for a particular subject	As a teacher, I want to teach with a gaming platform that is fun and yet challenging, so that learners are encouraged to learn more after failure.	Yes			
3	**How do teachers mitigate classroom challenges (Class motivation)**	Support fun, user friendly environment for both learners and teachers	As a teacher, I want to offer lesson in a fun and user friend gaming platform, so that both me and learners can enjoy the lessons	Yes			
4	**Do play computer games?**	Support gaming stages(levels)	As Teacher, I want to have options to choose the different levels of games, so that I can test my knowledge of how good I am.		Yes		
8	**How often do you play computer games?**	Support gaming level for beginners and intermediate	As a Teacher, I want to have an option to progress to different stages of the level of the game, so I can see my progression.			Yes	

9	**Devices used to play games (what kind of devices are used to play computer games)**	Supporting gaming that will run on smart phones	As a Teacher, I want have access to GBL on smart phones, so that I can be able to access learning material at any given point in time.				
10	**Game play competency (how good is the learner or teacher in playing games?)**	Must support different level of difficulty that are interconnected	As a Teacher, I want to be able to select one level of the game, so that I can progress to another level.		Yes		
11	**Type of games preferred (what type of games do you like?**	Type of games required for learning puzzles and word games, as well as simulation games	As a Teacher, I want to teach using digital educational games in a form of Puzzles or Word games, so that learners can learn better while having fun.			Yes	
12	**GBL for better classroom learning**	Support educational outcomes where results of each subject are displayed at the end of the game.	As a Teacher, I want the learners to learn and answer questions on GBL, so that they can see their results	Yes			
13	**GBL to help improve challenging subjects**	Support problem solving games and making it fun to teach and learn	As a Teacher, I want to teach on GBL while having fun, so that learners can grow to love the school subject they r learning.	Yes			

Table 4.8: Scrum session with teachers – Non-functional requirements

Prioritization of User Stories by both Teachers and Learners (Non – Functional Aspects) using MoSCoW							
S/N	Themes	Features	User stories	Must have (M)	Should have (S)	Could have (C)	Will not have (W)
1	**Learners' and Teachers access to electronic resources.**	**Compatibility** - Support gaming on smart phones	As a user, I want to have access to GBL platform via a smart phone, so that I can start my learning.	Yes			
		Portability - must be able to run Google Play store and Apple app store	As a user, I want to be able to download GBL on Google Play store or Apple App, so that I can start my learning	Yes			
		Accessibility – able to access electronic devices at school	As a user, I want to be access to electronic devices at school, so that I can access to GBL platform.	Yes			
2	**Learner's and Teachers computer literacy**	**Ease of use: Learnability** – support how fast and easy the learners can complete the main actions once they see the interface	As a user, I want to be able to easily navigate through GBL platform, so that I can quickly and easily complete my learning.	Yes			
3	**Do play electronic games?**	**Performance –** system must be able to handle multiple of learner's login simultaneously	As a group of users, we want to be able to login on GBL platform simultaneously, so that we can complete educational task as a group.	Yes			
		Scalability – the system must be scalable enough to support 60 user's logins at the same time while maintaining optimal performance	As a group of learners and teachers, we want to be able to login to GBL without failure, so that lessons can begin.	Yes			

4	**How often do you play computer games?**	**Performance** – the landing must be able to support 50 to 100 users per hour at 6 second or less response time	As a group of learners and teachers, we want to be able to login to GBL platform as quick as possible without delays, so that lessons can begin.	Yes			
5	**Game play competency**	**Reliability –** system must run without failure during school hours,95% of the time.	As a user, I want to be able to login to GBL at any given time during school hours without failure, so that I can catch up on my work or do school revision on my work.		Yes		
		Availability – the learning system must be accessible during school hours.	As a user, I want to be able to login to GBL platform at any given time during school hours, so that I can catch up on my work or do school revision on my work.		Yes		
		Security – learner's data on the system must be protected against Malware or unauthorized access.	As a user, I want my login details and any information on GBL platform must be secured, so that malware or unauthorized access must be prevented	Yes			

4.4. Summary

This chapter explained in details of how requirements elicitation, requirements analysis and requirements prioritization was done. Requirements elicitation was done by distributing questionnaires to township schools, and thereafter analysis on the data based on the questionnaires was done. Requirements analysis started from results of the questionnaires. Scrum activities then commenced based on the results, where user stories where formulated and presented to learners and teachers for prioritization.

This chapter also presented the design of a Scrum-based RE framework which was based on facts extracted from the literature. The framework illustrates how scrum was applied following a RE process to identify the requirements needed for web GBL platform for township schools. During scrum sessions, the functional and nonfunctional requirements associated with the user stories were identified and prioritized. The list of requirements was thereafter sent to the specialists in software development for evaluation.

5. CHAPTER FIVE: REQUIREMENTS QUALITY EVALUATION

This chapter reports the process of evaluating the requirements identified during scrum sessions. The identified requirements were sent to a group of specialists in the software development industry for evaluation. The experts that evaluated the requirements are Software Developers, Analyst Developers, Business Analyst (BA) and System Analysts (SA). The conclusion of this study was derived based on outcome of the evaluation.

5.1. Requirements Validation Process

The Scrum- based RE framework (Figure 4.5) was the process followed to identify requirements after having scrum session with the school learners and teachers. The set of functional and non-functional requirements that were derived and prioritized based on the interaction with the school stakeholders. The requirements were sent to a group of experts to review and evaluate the quality of requirements. A requirements quality rating document was prepared and sent to a group of experts together with the list of requirements to be revaluated. Table 5.1 presents an overview of the evaluator's participation, while Table 5.2 presents the experience and background of the evaluators.

Table 5.1: Overview of the evaluator's participation

Experts Names	Role	Total Participation	
		Selected	Responded
Group A	Developers	4	3
Group B	Analyst Developers	2	2
Group C	Business Analysts	4	2
Group D	System Analysts	4	2
Total number of participants approached			14
Total number of participants that responded			10

Table 5.2: Experts' Experience and Background

Experts Names	**Role**	**Years Experience**	**Summary of the role**
Group A	Developer A	17 years	Make changes and/or create new programs according to the business requirements. Have been in a role where they had to gather the requirements from the users.
	Developer B	10 years	Designing computer programs

	Developer C	10 years	fixing root causes, doing daily support
Group B	Analyst Developer D	30 + years	Jack of all trades. Previously Solutions architect, now modernising core applications. Spend 5 years as a Solutions architect applying the principles of TOGAF.
	Analyst Developer E	i. Developer: 2 Years & 7 Months ii. Business Analyst: 11 Months iii. Systems Analyst: 3 Yeats & 5 Months	Developer: i. Bug Fixes & Maintenance ii. New Feature Development Business Analyst: iii. Create & Maintain BPMN, BRD, Use Case Diagram & User Stories Systems Analyst: iv. Create & Maintain the Network Diagrams, Activity/Flow Diagrams & SRS v. Facilitate & Lead Technical Discussions vi. Make & Communicate Technical Decisions & Impact
Group C	Business Analysts A	10 years	i. Preparation and planning of deliverables. ii. Workshop Facilitation. iii. Elicitation of requirements. iv. Documenting of requirements. v. Process Modelling. vi. UAT Test Case Creation. vii. Peer review of artefacts created. viii. Support and training of BA team
	Business Analyst B	13 years	i. Requirements Analysis ii. Functional Requirements Documentation

			iii. Process Modelling iv. Functional Design Specification v. Test Scripts and user guides Compilation vi. Manages Services Operational Management vii. User Acceptance Testing
Group D	System Analysts	1 Year 5 months	Finding common ground between the non-technical and technical requirements of a system, while working closely with the BA and Developer to create and manage the system capabilities. Worked as a Solutions architect before where Requirements engineering was one of the main tasks as I was closely with SME's.
	System Analyst	7 years	Analysing requirements for changes to existing systems and new systems, also draw up technical impact documents and writing technical documents that support the developer to execute on the requirements. Testing of existing API services and analysis of the changes. Database specifications to ensure standards and protocols are followed and data integrity is preserved.

5.1.1. Assessment of Requirements Quality

Assessing the quality of requirements is not a simple task, mainly by the multitude of the proposal, of the attribute to be evaluated and the methodologies used. It is therefore important to consider proven quality model for guide the evaluation process (Saavedra, Ballejos & Ale, 2013). This study used a combination of

the Weiger's requirements quality model (Weigers, 2003) and Pohl requirements quality model (Pohl, 2010) for the evaluation of the identified requirements.

Table 5.3 show the set of requirements that was sent to the experts for evaluation. It includes the list of functional and non-functional requirements which was sent as a Microsoft excel document.

Table 5.3: Functional Requirements sent for rating.

Functional Requirements for a Game-Based Learning Web Platforms for Grade 1 -12 Township Schools			
Requirements ID	**Requirements**	**Explanation**	**Prioritization (MoSCoW)**
RE01	The system must provide Multiplayer environment so that learners can collaborate with each other while learning.	The system must allow more than one player at a time	Must have
RE02	The system should support single player environment so that learners can learn alone.	The system should allow a single player mode for a person that prefers such	Could have
RE03	The system must allow both teachers and learners to play a game simultaneously, so that users can collaborate with each other	The system must promote collaboration between learners and teachers	Must Have
RE04	The system should provide feedback to the users in a form of musical scores or results so that users can see their progress	The system should provide music sounds or results as the users are busy with the game	Should have
RE05	The system must provide interactive learning and feedback, so that users can have the desire to learn more	The system should have games that test learners on the ability to think logically and critically	Must Have
RE06	The system should have games that require users to perform logical and critical reasoning tasks, so that users can stimulate their minds	The system should have games that test learners on the ability to think logically and critically	Should Have
RE07	The system must have games that requires users to solve mathematical problems so that users can stimulate their logical thinking	The system must include games that test knowledge on mathematical equations/problems	Must have
RE08	The system must be accessed by users on all digital platforms such a web and smart phones so that learners, so that learners can access the educational games anytime, anywhere.	The system must allow the users to access it using a electronical device such as smart phones, computers	Must Have
RE09	The system should provide users with an option to select the level of difficulty of the game, so that users can play according to the level of expertise	The system should have an option for users to select the gaming level they want to play	Should Have
RE010	The system must be playable on a smart phone	They system must work on all smart phone devices such as playstore	Must Have
RE011	The system should enable users to advance to higher levels of	The system must allow users to advance to higher levels based on their performance.	Should Have

	difficulty of the game based on previous performance		
RE012	The system should consist of games such as puzzles, word games, and simulation games for learning purposes.	The system should consist of games such as puzzles, word, mathematical games	Should Have
RE013	The system must support design features such as visual aesthetics, so that learners can have more interest in playing the educational game	The look and feel of the system must have appealing or pleasing appearance to the users	Must Have
RE014	The system must give feedback in a form of musical scores when a user plays the educational games, so that learners can have fun while playing the game.	The system must respond back to the users in a form of sounds when using the game	Must have
RE015	The system must offer rewards at every stage of the game, so that the learners can get inspired to be at their best when playing the educational game.	The system must respond back with a reward at the end of each stage or game	Must have
RE016	The system must offer challenging games that can allow learners to work as a group while competing one another.	The system must offer games that are challenging enough as learners work as group	Must have
RE017	The system must allow learners to answer questions based on a particular subject in a pop- up dialogs and get evaluated by the system, so that student can test their knowledge on particular subjects	The system must offer games based on their school subjects/ curriculum	Must have
RE018	The system must at end of each game, give results of the questions asked for each school subject, so that learners can see the results of school subjects they were tested on.	The system must give feedback to the users in a form of results to the questions asked	Must have
RE019	The system must enable interactive problem solving so that learners can have fun while learning.	The system must include problem solving games	Must have

Table 5.4: Non-functional requirements

Non-Functional Requirements for a Game-Based Learning Web Platforms for Grade 1 -12 Township Schools			
Requirements ID	**Requirements**	**Explanation**	**Prioritization (MoSCoW)**
NFR01	The system must maintain availability of 99.99%.	The expected percentage/ time the system does successful request, as well as expected percentage the system is accessible for operation during a specific period.	Must have
NFR02	The system must operate on smart phone platforms, so that learners learn using smart phones.	The hardware and software environments that the system will operate or run on.	Must have

NFR03	The system must be able to run on Google play store and Apple app store, so that learners and teachers can download educational games of their phones and laptops.	The system must be able to run on google play store, Apple app store, as well as web application environments	Must have
NFR04	The system must be easy to use and user friendly to allow both learners and teachers to seamlessly interact with the product.	Users must be able to learn and use the system effectively and easily.	Must have
NFR05	The system must be able to handle multiple of learner's login simultaneously.	It is the measure in time which the system can respond under different load conditions	Must have
NFR06	The system must be scalable enough to enable multiple user logins at the same time while maintaining optimal performance	Defines the highest workloads/logins which the system will still meet the performance requirements	Must have
NFR07	The system's response must be able to support multiple users per hour at 2 second or less response time	Specifies how fast can the system respond to a certain user's action under a given/ certain workload	Must have
NFR08	The system must run without failure 95% of the time.	Specifies the probability of software performance without failure when the system is in use a number of times	Should have
NFR09	Learners and teacher's data on the system must be protected against Malware or unauthorized access	The system must be protected from Malware attacks and unauthorized access	Must have
NFR010	The system must be built in such a way that it can allow future development	The coding should support Object oriented programming	Should Have

The evaluation document sent to the experts highlighted specific attributes for quality rating of the requirements. A consolidation of the requirements quality metrics from the Weiger's requirements quality model (Weigers, 2003) and Pohl's requirements quality model (Pohl, 2010) was done to derive the quality attributes that were used for the evaluation. The requirements attributes that were evaluated are in two categories, which are individual requirements, and the requirements set.

- The quality attributes for rating of individual requirements:
  i) **Complete**: *Each requirement is complete and adheres to the rules and guidelines defined for its type and does not omit any information that is relevant to some stakeholder*,
  ii) **Traceable**: *Each requirement is traceable because the source, evolution, impact, and use can be associated with specific features that are expected in the system*,
  iii) **Correct***: Each requirement is correct, and the relevant stakeholder can approve it 's correctness*,

iv) **Unambiguous**: *Each requirement is unambiguous because there is only one valid interpretation in each case,*

v) ***Comprehensible:*** The content of each requirement is easily understandable,

vi) **Consistent*:*** *Each requirement regarding the artifact is consistent and does not contradict each other,*

vii) **Verifiable:** *Each requirement is verifiable because it corresponds to the features expected in the implemented system,*

viii) **Rated/Prioritized***: Each requirement is rated because it's relevant or stability have been identified and documented,*

ix) ***Up to Date:*** *Each requirement reflects the current status of the system and its context,*

x) **Atomic***: Each requirement is atomic because it represent a single, coherent fact.*

❖ The attributes that focused on the requirements as a set:

i) **Completeness:** *The set of requirements is complete, and all relevant requirements are specified in full details,*

ii) **Consistency:** *The set of requirements is consistent because all specified requirements are consistently defined,*

iii) **Modifiability:** *The set of requirements is modifiable because it's structure and style support a simple, consistent, and complete modification of the requirements while maintaining its structure and style,*

iv) ***Traceable:*** *The set of requirements can be linked back to the original design, implementation and testing that verify the correctness of the implementation.*

v) **Readability:** *The set of requirements is readable, and the reader can easily understand them.*

Table 5.5 shows a sample of the sheet that was used by experts in the field to rate both individual requirements and requirements as a set.

Table 5.5: Rating of Requirements

Rating of individual requirements						
Attributes	**Description**	**Very Good (5)**	**Good (4)**	**Average (3)**	**Poor (2)**	**Very Poor (1)**
Complete	Each requirement is complete and adheres to the rules and guidelines defined for its type and does not omit any information that is relevant to some stakeholder					
Traceable	Each requirement is traceable because the source, evolution, impact, and use can be associated with specific features that are expected in the system.					
Correct	Each requirement is correct, and the relevant stakeholder can approve it 's correctness.					
Unambiguous	Each requirement is unambiguous because there is only one valid interpretation in each case.					
Comprehensible	The content of each requirement is easily understandable					
Consistent	Each requirement regarding the artifact is consistent and does not contradict each other					
Verifiable	Each requirement is verifiable because it corresponds to the features expected in the implemented system.					
Rated/Prioritized	Each requirement is rated because it's relevant or stability have been identified and documented					
Up to Date	Each requirement reflects the current status of the system and its context					
Atomic	Each requirement is atomic because it represent a single, coherent fact					
Rating of requirements set						
Completeness	The set of requirements is complete, and all relevant requirements are specified in full details					
Consistency	The set of requirements is consistent because all specified requirements are consistently defined.					

Modifiability	The set of requirements is modifiable because it's structure and style support a simple, consistent and complete modification of the requirements while maintaining its structure and style					
Traceable	The set of requirements can be linked back to the original design, implementation and testing that verify the correctness of the implementation.					
Readability	The set of requirements is readable, and the reader can easily understand them					
General Comments on the quality of requirements:						

5.1.2. Requirements Rating Results

Table 5.5 shows how the requirements are rated by specialist. The range for the rating of each attribute is on scale of 1-5. The rating value 5 for ‘very good’ to 1 is for ‘very poor’. While table 5.6 shows the rating provided for each quality attribute by evaluator that assessed the requirements. The results from the rating of requirements, and the mean (average) rating for each quality attribute were analysed by using the mean value approach. The mean value is the average value of a dataset (Edward & Livingston, 2003). The mean(average) value of each requirement attribute after aggregating the ratings of all the evaluators.

Table 5.6 Individual Requirements Rating Results

Individual Attributes Values	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Expert 7	Expert 8	Expert 9	Average Rating
Complete	4	5	5	4	5	4	4	3	5	5
Traceable	3	5	5	5	4	4	5	3	5	5
Correct	3	5	5	3	4	5	5	4	5	5
Unambiguous	3	5	4	3	4	4	5	4	5	4
Comprehensive	4	5	5	4	5	5	5	3	5	5
Consistent	4	5	5	5	4	4	5	4	5	5
Verifiable	3	5	5	5	4	4	5	3	5	5
Rated/Prioritized	3	5	5	5	5	5	5	5	5	5
Up to Date	3	5	5	5	5	4	5	5	5	5
Atomic	4	5	5	4	4	4	5	4	5	4

Table 5.7 Rating Results of Requirements Set

Individual Attributes Values	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Expert 7	Expert 8	Expert 9	Average Rating
Complete	4	5	5	4	4	5	5	3	5	5
Consistency	3	5	5	4	4	5	5	4	5	5
Modifiability	4	5	5	4	5	5	5	4	5	5
Traceable	3	5	5	3	4	5	5	3	5	5
Readability	4	5	5	5	5	5	5	4	5	5

Based on the evaluators' ratings of the individual requirements (see. Table 5.6), each of the quality attributes: Complete, Traceable, Correct, Comprehensive and Consistent, Verifiable, Rated/Prioritized and Up to date had a mean rating of 5 which connotes very good. The requirements quality attributes, Atomic and Unambiguous each had a mean rating of 4, which corresponds good quality.

The mean rating of the set of requirements by the evaluators shows the quality attributes: Completeness, Consistency, Modifiability, Traceable and Readability each had a mean rating of 5 from the evaluators, which connotes 'very good' (see. Table 5.7). The results suggests that most of the evaluators found the requirements set to be very good.

5.2. Requirements Management

Some of the evaluators provided feedback based on their assessment of the requirements. Requirements management (RM) was done to amend the requirements as per the evaluators feedback. Requirements management is one of the crucial phases in requirements engineering that describes the ability to write requirements and make them readable and traceable with the aim to follow their step-by-step evolution over time (Lanzotti et al.,2023). Requirements management (RM) is a process that cover the entire software development cycle ensuring that the features of the software are update with changes in requirements during the period of development of the software product. Therefore, Requirements management (RM) was partially achieved in this thesis because the scope of the study does not include the software development of the GBL platform.

Some of the comments-based on the assessment of the requirements are as follows:

Expert 2: "The requirements are well-written & easy to understand, they provide a clear picture of what the system needs to do; are crystal clear & I can't see any room for misunderstanding or confusion; are very specific & easy to test, there should be no trouble verifying that the system meets them; seem reasonable & achievable within the project's constraints". Expert 2 also said "I also appreciate the level of detail in these requirements. It's clear that a lot of thought has gone into making sure that nothing important has been left out. I'm sure that these requirements align with the business needs. I like how these requirements are organized by priority, it's very helpful to know which features are the most important to focus on."

Furthermore, Expert 5: "The requirement is perfect as it meets all the characteristics of a good requirement. It will be easy to follow this requirement for any developer who will be interested to build the game-based learning web platform."

Expert 7: "This is a good example of perfect requirements; they are direct and leave no room for interpretation."

Expert 4: “The requirements are obviously documented at a fairly high level, and I therefore I rated them accordingly. A few of the requirement statements were open for interpretation, however, most were easy to understand. I would try avoiding writing requirements as must and should as they can rather be categorised by the Moscow method. To make it easy to separate requirements I write them as “… will need to” and keep the “must” statement for rules (just a suggestion). The requirement statements are short and concise which is a good as it helps maintain their clarity. There are however a few requirement statements that were a bit ambiguous which would require the BA to go back to their stakeholders to obtain some clarification. I think the key elements of what the App would need to achieve was fairly well articulated. Meaning the validity and traceability were covered quite well.”

Expert 9: “The requirements are clear and precise. As you read them you can already visualise the design and implementation thereof. These are perfect as there is no confusion as I read each one. Its detailed and readable.”

There are some evaluators; Expert 1 and Expert 8 made recommendations that some requirements that are listed as functional requirements are in fact non-functional requirements.

Expert 1: “Some of the functional requirements, RE03, 05, 08, 10, 13 & 16 should be under non-functional requirements.”
Expert 8:” The non-functional requirements are clear and well documented. The functional requirements need improvement to provide clarity on the below:
When the user accesses the site, do they have to enter the credentials?
Are the system rights and or functionality different between learners and teacher?
Can the user create their own account on the website and/or mobile application?
Do the teachers assign the games to the learners, or the learner choose their preferred games?
There are also some non-functional requirements that are also noted as functional requirements, e.g.: The system(game) must be playable on a smart phone. I think the order that the requirements are listed can also be improved to group the requirements based on a feature. This will make it easy for the developer to translate the requirements for each feature.”

As per the above comments from expert 1 and 8 who recommended that user access functionality must be added to the functional requirements so it is clear on how the system will be accessed by the users. This included system rights and permission allocated to the users for login purposes.

From the comments of the evaluators, the researcher then corrected the requirements based on the recommendations of the evaluators. The requirements are presented below as per specialist recommendations. As per the specialist evaluation and ratings, the requirements generated were found to be complete, correct, consistent, and traceable individually and as a set. Furthermore, the individual requirements were found to be Unambiguous, Comprehensive, Rated/Prioritized, Up to Date, Verifiable, and Atomic. While as a set of requirements, they were found to be very good in Modifiability and readability.

Table 5.8 show the set of Functional requirements that was amended after the Experts evaluation. The amendments to the requirements are highlighted in light blue.

Table 5.8 Functional Requirements amended based on expert feedback.

Functional Requirements for a Game-Based Learning Web Platforms for Grade 1 -12 Township Schools			
Requirements ID	Requirements	Explanation	Prioritization (MoSCoW)
RE01	The login screen must allow registered learners or teachers to login to access all features that their account gives them access to	Users access to game-based learning by entering credentials	Must have
RE02	Learners and Teachers will have different system rights when accessing the system	Different system rights for the learners and teachers	Must have
RE03	The system must allow users to create their own account on the website or mobile app	the system user profile to access the system	Must Have
RE04	The system must provide Multiplayer environment so that learners can collaborate with each other while learning.	The system must allow more than one player at a time	Must have
RE05	The system should support single player environment so that learners can learn alone.	The system should allow a single player mode for a person that prefers such	Could Have
RE06	The system should provide feedback to the users in a form of musical scores or results so that users can see their progress	The system should provide music sounds or results as the users are busy with the game	Should Have
RE07	The system should have games that require users to perform logical and critical reasoning tasks, so that users can stimulate their minds	The system should have games that test learners on the ability to think logically and critically	Should Have
RE08	The system must have games that requires users to solve mathematical problems so that users can stimulate their logical thinking	The system must include games that test knowledge on mathematical equations/problems	Must have
RE09	The system should provide users with an option to select the level of difficulty of the game, so that users can play according to the level of expertise	The system should have an option for users to select the gaming level they want to play	Should have
RE010	The system should enable users to advance to higher levels of difficulty of the game based on previous performance	The system must allow users to advance to higher levels based on their performance.	Should Have
RE011	The system should consist of games such as puzzles, word games, and simulation games for learning purposes.	The system should consist of games such as puzzles, word, mathematical games	Should Have
RE012	The system must give feedback in a form of musical scores when a user plays the educational games, so that learners can have fun while playing the game.	The system must respond back to the users in a form of sounds when using the game	Must have

RE013	The system must offer rewards at every stage of the game, so that the learners can get inspired to be at their best when playing the educational game.	The system must respond back with a reward at the end of each stage or game	Must have
RE014	The system must offer challenging games that can allow learners to work as a group while competing one another.	The system must offer games that are challenging enough as learners work as group	Must have
RE015	The system must allow learners to answer questions based on a particular subject in a pop- up dialogs and get evaluated by the system, so that student can test their knowledge on particular subjects	The system must offer games based on their school subjects/ curriculum	Must have
RE016	The system must at end of each game, give results of the questions asked for each school subject, so that learners can see the results of school subjects they were tested on.	The system must give feedback to the users in a form of results to the questions asked	Must have
RE017	The system must enable interactive problem solving so that learners can have fun while learning.	The system must include problem solving games	Must have

Table 5.9. Non-Functional Requirements amended based on expert feedback.

Non-Functional Requirements for a Game-Based Learning Web Platforms for Grade 1 -12 Township Schools			
Requirements ID	Requirements	Explanation	Prioritization (MOSCOW)
NFR01	The system must maintain availability of 99.99%.	The expected percentage/ time the system does successful request, as well as expected percentage the system is accessible for operation during a specific period.	Must have
NFR02	The system must operate on smart phone platforms, so that learners learn using smart phones.	The hardware and software environments that the system will operate or run on.	Must have
NFR03	The system must be able to run on Google play store and Apple app store, so that learners and teachers can download educational games of their phones and laptops.	The system must be able to run on google play store, Apple app store, as well as web application environments	Must have
NFR04	The system must be easy to use and user friendly to allow both learners and teachers to seamlessly interact with the product.	Users must be able to learn and use the system effectively and easily.	Must have
NFR05	The system must be able to handle multiple of learner's login simultaneously.	It is the measure in time which the system can respond under different load conditions	Must have

NFR06	The system must be scalable enough to enable multiple user logins at the same time while maintaining optimal performance	Defines the highest workloads/logins which the system will still meet the performance requirements	Must have
NFR07	The system's response must be able to support multiple users per hour at 2 second or less response time	Specifies how fast can the system respond to a certain user's action under a given/ certain workload	Must have
NFR08	The system must run without failure 95% of the time.	Specifies the probability of software performance without failure when the system is in use a number of times	Should have
NFR09	Learners and teacher's data on the system must be protected against Malware or unauthorized access	The system must be protected from Malware attacks and unauthorized access	Must have
NFR010	The system must be built in such a way that it can allow future development	The coding should support Object oriented programming	Should Have
NFR011	The system must allow both teachers and learners to play a game simultaneously, so that users can collaborate with each other	The system must promote collaboration between learners and teachers	Must have
NFR012	The system must provide interactive learning and feedback, so that users can have the desire to learn more	The system must promote the users with the ability to want to learn more as they play the game	Must have
NFR013	The system must be accessed by users on all digital platforms such a web and smart phones so that learners, so that learners can access the educational games anytime, anywhere.	The system must allow the users to access it using a electronical device such as smart phones, computers	Must have
NFR014	The system must be playable on a smart phone	They system must work on all smart phone devices such as play store	Must Have
NFR015	The system must support design features such as visual aesthetics, so that learners can have more interest in playing the educational game	The look and feel of the system must have appealing or pleasing appearance to the users	Must have

5.3. Summary

This chapter elaborated in detail how the requirements were evaluated by experts in the field of software development. As well how Requirements Management (RM) was done to amend the list of requirements based on the evaluation of the experts. It was also noted that RM could not be done in full because this study only focuses on identifying the requirements and not the full life circle of software development. The requirements generated in this study, which were based on specific attributes, are noted by the evaluators as very good, and can be used as part of the specifications when further studies are done on GBL. Particularly, if specialist in the field want to develop and implement GBL in townships schools around South Africa. It is important to first note done the requirements and perhaps even add more to the already specified requirements.

6. CHAPTER SIX: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

The aim of this study is to identify the requirements for game-based learning web platform for grade R-12 learners in South Africa that is based on the scrum approach. For the Researcher to achieve this goal design science research (DSR) was applied while mapping the objectives of the study to the different phases of DSR.

6.1. Summary of the study

The study is divided into Six chapters and each chapter has a different topic. Firstly, in chapter 1 and 2. The literature review, the study discussed what is Game-based learning and why it important. As well as all relevant terms related to GBL. Furthermore, challenges around the adoption of gamed based learning were also discussed. Then the study highlighted the challenges that currently exists in South African school educations. It is based on these challenges the study elaborated on why the need for GBL learning in South Africa. Related work was done to explain the need for GBL in South Africa.

The research problem was identified as the lack of a thorough understanding of the requirements needed to build a digital game-based learning platform, even though GBL has been identified as a possible solution to the challenges of learning for grade R-12 learners in schools.

Therefore, the study looked into the requirements needed to build a digital game-based learning (DGBL)platform for schools in South Africa, particularly in disadvantaged communities. Requirements Engineering (RE) process was then applied throughout this study to identify the requirement for DGBL. Scrum, the Agile methodology was used to interact with the school stakeholders to identify the requirements.

The following presents how the study achieved each objective that was outlined:

i. **To determine the type and mode of GBL that is relevant to Grade R-12 students in South Africa.**

   To achieve the first objective, Requirements Elicitation phase was initiated, Requirement Elicitation entails a computer-based process which is used for seeking, uncovering, acquiring, and elaborating requirements according to the stakeholder's needs and wants (Zowghi & Coulin, 2005; Laplante & Kassab,2022). Data was initially collected via a survey by distributing the survey to five townships schools in the Western Cape province of South Africa. Data received from the survey respondents was stored MS Excel for analysis. Data analysis then commenced and information that was vital and applicable to learners and teachers were extracted from the data.

The study found that most students identify themselves as verbal or social learners, friendly or talkative in terms of personality and preferred learning style, respectively. There was also a fewer but significant percentage of learners with shy or quiet personalities in the sampled population. As well as those also learners that identified themselves as solitary learners who prefer to study alone, while a few indicated their preference for visual learning.

Most learners play games and love to play games, mainly using smartphones. Puzzles and video games are the most popular among learners, while simulation, word games, and card games are also popular. Games that incorporate aspects of visual aesthetics, musical scores and incentive systems are liked by most learners. There is also a preference for games that involves a challenge, enable competition with peers, and promotes curiosity. Thus, generally, multiplayer game platforms that are rich in these social interaction features are desirable for SA learners. There is also a need for single-player game platforms that can stimulate logical thinking and logical reasoning, which can help learners develop logical abilities that will make difficult subjects such as Mathematics, Mathematical Literacy, Pure Science, Accounting, and Geography easier to learn.

ii. To design a RE framework for a GBL web platform based on Scrum.

Based on the results of the requirements elicitation, a design of the of RE framework was initiated. A proposed scrum based RE Framework for GBL was developed as template of how Scrum activities together with RE processes will be done throughout the study to achieve the aim of the study. The scrum based RE process flow was derived from which the activities of the RE framework were specified. The scrum-based RE framework contains the activities needed to identify the requirements of a web-based game-based learning platform for grade R-12 learners.

iii. To demonstrate how to apply the Scrum-based RE framework for specification on requirements for GBL web platform for grade R-12 learners.

The specified activities of the Scrum-based RE framework were executed iteratively to of identify the requirements for the GBL platform. User stories were formulated by the researcher and presented to the learners and teachers via Scrum sessions. From User stories, requirements were formulated and prioritized by stakeholders via Scrum sessions. After requirement prioritization, a requirements document was written and presented to a group of experts for evaluation. By applying this Scrum-based RE framework, requirements were formulated and sent to a group of experts to evaluate the quality of the specified requirements specified.

The process flow / Framework formulated can be used by researchers or experts in the fields to gather requirements to develop DGBL platforms. It serves as a guideline on the steps to follow when in the process of implementing DGBL platforms in schools, particularly disadvantaged schools.

iv.*To evaluate the quality of the requirements obtained through the application of the Scrum-based RE framework for GBL web Platform for grade R-12 learners.*

A requirement evaluation document prepared and was sent to a group of software development experts to evaluate the quality of requirements based on specific requirements quality attributes. The quality attributes by were based on metrics of Weiger's requirements quality model (Weigers, 2003) and Pohl's requirements quality model (Pohl, 2010). The evaluators consist of Software Developers, Business Analysts, and System Analysts. The results of the evaluation showed that for:

iv. Individual requirements: the attributes: Complete, Traceable, Correct, Comprehensible, Consistent, Verifiable, Rated/Prioritized, and Up to Date had a mean rating of 5 (very good quality), while two attributes, atomic, and Unambiguous had a mean rating of 4, which denotes good quality.
v. The requirements set: All attributes: Completeness, Consistency Modifiability Traceable and Readability has a mean rating of 5, which connotes very good quality.

The evaluators also commented that generally, the requirements were well documented, clear, and easy to understand. They also commented that the requirements provided a clear picture of the solution of the GBL learning environment.

6.2. Contributions of the study

As a contribution, this study has provided insight into the type and mode of GBL that is preferred by SA learners, which is a topic that has gained limited or no attention before now. Thus, the insight from the study provides a first empirical basis for understanding the requirements of a digital GBL for learners in SA, which is also relevant to other developing countries that share contextual characteristics with South Africa. Another contribution is the steps provided by the scrum RE process flow, which can be followed as guideline for any researcher who wants to gather requirements needed for GBL platforms in South Africa.

i. Theorical contribution

In Contrast to the knowledge that already exist for GBL, the study extends what is currently known about GBL through the application of scrum-based RE for the design of a web-based GBL learning in the context of South Africa.

ii. Practical contribution

This study has practical relevance for game developers and software developers as it will improve the quality of their e-learning solutions. It will also contribute to school learning for teacher and students when GBL is fully developed. The steps provided by the scrum-based RE process workflow, and the Scrum-based RE framework, which can be followed as guideline for any researcher who wants to gather requirements needed for GBL platforms in South Africa.

6.3. Limitation of the study

During Scrum sessions in schools, it was discovered that most of the schools do not have the necessary infrastructure for an effective implementation of GBL platforms. Most schools in disadvantaged communities do not have computer labs, there is no wireless internet connectivity (Wi-Fi) in some of these schools. Another minor limitation is some schools is that students are not allowed to use their cellphone on school grounds. As a results of this limitation, it was very difficult for researchers to do prototyping for GBL platforms in such schools as there is no proper infrastructure to do so. Prototyping would have helped to test how fast the learners and teachers will be able to adopt to GBL platforms should such platforms be implemented within their school environment.

6.4. Recommendations

For more research to be done on GBL platforms in south Africa, the research must be loud enough to get the attention of the South African education system response to invest more in the required facilities to implement these educational platforms, particularly in disadvantaged schools. Resources that support GBL must be implemented so that relevant practical work can be done in these schools.

The government should consider having computer labs in schools for learners to start having computer classes and prototyping purposes on GBL, even if it is just two labs per school. Some schools in Gauteng have gone digital. Learners are equipped with tablets and WIFI to learn while using tablets, and teachers are equipped with smart boards to facilitate learning (Patel, 2018). Research done in one of the schools highlights that since the school started using digital equipment, the learners' results have improved, especially in maths and science (Patel, 2018). The same can be done for the rest of the disadvantaged schools in the country, for the government to ensure the schools have digital classrooms, particularly the Western Cape. Another possible solution could be donating about 10- 50 tablets by the government or private sector for prototyping purposes to test the effectiveness of GBL in the classrooms. These tablets could be loaned until research is done, or the tablets can be given to one school for learners to use after the research.

6.5. Further research

Further research is needed on GBL platforms in South Africa as the tools have not really found fit in this country. Prototyping is essential in South African schools as it will determine how effective and efficient will GBL be adopted in township schools. Research has revealed that to ensure the pedagogical foundation of a game is met; one needs to consider the fit of the game. The fit means the goal of GBL must match the student’s learning task (Mosiane & Brown; 2020). The fit between education games and the learning task is of important because if the two factors don’t align then the learning outcome’s effectiveness decreases (Brom, Šisler and Slavík, 2010). Therefore, future GBL researchers need to consider prototyping the already mentioned type of games for township schools in SA to test the effectiveness of the education game for these specific learners.

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APPENDICES

Appendix A: Individual consent letter

Cape Peninsula University of Technology

Introductory letter for the collection of research data

Makhasane Precious Mamotheti is registered for the Master in Information Technology (MICT) degree at CPUT (217236456). The thesis is titled: Research Proposal -Scrum Requirements Engineering for a Game-based Learning Web Platform for Grade R – 12 learners in South Africa.

To create a requirements engineering (RE) Framework for a game-based learning web platform for grade R-12 learners in South Africa that is based on the scrum approach. The supervisor(s) for this research are:

- Prof Justine Olawande Daramola

In order to meet the requirements of the university's Higher Degrees Committee (HDC) the student must get consent to collect data from organisations which they have identified as potential sources of data. In this case the student will use semi-structured interviews to gather data.

If you agree to this, you are requested to complete the attached form and print it on your organisation's letterhead.

For further clarification on this matter please contact either the supervisor(s) identified above, or the Faculty Research Ethics Committee secretary (Ms V Naidoo) at 021 469 1012 or naidoove@cput.ac.za.

Yours sincerely,

Prof Justine Olawande Daramola

08 January 2021

Appendix B: Ethical clearance

Western Cape Government
Education

Directorate: Research

meshack.kanzi@westerncape.gov.za
Tel: +27 021 467 2350
Fax: 086 590 2282
Private Bag x9114, Cape Town, 8000
wced.wcape.gov.za

REFERENCE: 20210504-2661
ENQUIRIES: Mr M Kanzi

Ms Makhasane Mamotheti
28 Stockside Road
Northpine
Brackenfell
7560

Dear Makhasane Mamotheti,

RESEARCH PROPOSAL: SCRUM REQUIREMENTS ENGINEERING FOR GAME-BASED LEARNING WEB PLATFORM FOR GRADE R – 12 LEARNERS IN SOUTH AFRICA.

Your application to conduct the above-mentioned research in schools in the Western Cape has been approved subject to the following conditions:

1. Principals, educators and learners are under no obligation to assist you in your investigation.
2. Principals, educators, learners and schools should not be identifiable in any way from the results of the investigation.
3. You make all the arrangements concerning your investigation.
4. Educators' programmes are not to be interrupted.
5. The Study is to be conducted from **3 May 2022 till 30 September 2022.**
6. No research can be conducted during the fourth term as schools are preparing and finalizing syllabi for examinations (October to December).
7. Should you wish to extend the period of your survey, please contact Mr M Kanzi at the contact numbers above quoting the reference number.
8. A photocopy of this letter is submitted to the principal where the intended research is to be conducted.
9. Your research will be limited to the list of schools as forwarded to the Western Cape Education Department.
10. The approval of your research request does not imply a promise of any data from the WCED. Should you require data, you will have to request it from the participating schools where it will be possible to secure parental consent.
11. Please note that POPIA prohibits the sharing of personal information without parental consent.
12. A brief summary of the content, findings and recommendations is provided to the Director: Research Services.
13. The Department receives a copy of the completed report/dissertation/thesis addressed to:

    The Director: Research Services
    Western Cape Education Department
    Private Bag X9114
    CAPE TOWN
    8000

We wish you success in your research.

Kind regards.

Meshack Kanzi
Directorate: Research
DATE: 3 May 2022

Cape Peninsula
University of Technology

HEALTH AND WELLNESS SCIENCES RESEARCH ETHICS COMMITTEE (HWS-REC)
Registration Number NHREC: REC- 230408-014

P.O. Box 1906 • Bellville 7535 South Africa
Symphony Road Bellville 7535
Tel: +27 21 959 6917
Email: sethn@cput.ac.za

17 February 2022
REC Approval Reference No:
CPUT/HW-REC 2022/S1

Faculty of Health and Wellness Sciences

Dear Ms MP. Mamotheti

Re: APPLICATION TO THE HWS-REC FOR ETHICS CLEARANCE

Approval was granted by the Health and Wellness Sciences-REC to **Ms MP. Mamotheti** for ethical clearance. This approval is for research activities related to research for **Ms MP. Mamotheti** at Cape Peninsula University of Technology.

TITLE: **Scrum Requirements Engineering for a Game-based Learning Web Platform for Grade R – 12 Learners in South Africa**

Supervisor: Prof Justine O Daramola

Comment:

Approval will not extend beyond 17 February 2023. An extension should be applied for 6 weeks before this expiry date should data collection and use/analysis of data, information and/or samples for this study continue beyond this date.

The investigator(s) should understand the ethical conditions under which they are authorized to carry out this study and they should be compliant to these conditions. It is required that the investigator(s) complete an **annual progress report** that should be submitted to the HWS-REC in December of that particular year, for the HWS-REC to be kept informed of the progress and of any problems you may have encountered.

Kind Regards

Mrs Carolynn Lackay
Chairperson – Research Ethics Committee
Faculty of Health and Wellness Sciences

Appendix C: Survey Questionnaires

Learners Questionnaire

Dear Learners,

This survey seeks to identify the features and requirements of game-based learning web platform for grade R- 12 learners in South Africa. Game- Based learning (GBL) is the use of games to facilitate the process of learning. Basically, it simply means you as will be using games to learn some of the subjects in the classroom. GBL is useful because it helps Learners persevere, stay engaged, adapt, stay motivated, think out of the box and learn from their mistakes while in the process of learning.

Please answer the following questions which will be exclusively used for data analysis in the research for Scrum requirements engineering for Game-Based learning web platform for Grade R-12 Learners in South Africa. All responses will be treated confidentially.

I, thank you for contributing to the study.

.....

Give your responses to the questions below indicating 'x' inside the ◯ or the ☐

Questions:

1. **What area is your school in (Select only 1)?**
   - ◯ City
   - ◯ Suburb
   - ◯ Township
   - ◯ Rural

2. **What do you like about your school?**
   - ☐ Teaching & learning facilities
   - ☐ Teachers attitude
   - ☐ Sports activities
   - ☐ My fellow students
   - ☐ Extra curricula activities (i.e. sports, music class or etc.)

3. **What do you dislike about you school?**
   - ☐ Difficult homework
   - ☐ Mean Teachers
   - ☐ lunch breaks
   - ☐ My fellow students
   - ☐ Bullies
   - ☐ Difficult Subjects
   - ☐ Simple Subjects
   - ☐ Exam time

4. **In what Grade are you in?** .....

5. **What is your Race (Select only 1)?**
   - ◯ Black
   - ◯ Coloured
   - ◯ White

6. **What is your Gender (Select only 1)?**

- ◯ Male
- ◯ Female

7. **How would you describe yourself?**
   - ☐ Social
   - ☐ Outgoing
   - ☐ talkative
   - ☐ Action-oriented
   - ☐ Friendly
   - ☐ Shy
   - ☐ Quiet
   - ☐ Reserved
   - ☐ thoughtful

8. **What kind of learner are you?**
   - ☐ I learn well with pictures and images (i.e. Visual)
   - ☐ I learn well with sounds and audio (i.e. Aural)
   - ☐ I learn well with the teacher speaking and writing (i.e. Verbal)
   - ☐ I learn better by doing (i.e. Kinesthetic)
   - ☐ I learn better by solving problems either by explaining and interpreting text or by solving mathematics problems - (i.e. Logical)
   - ☐ I learn better by exchanging ideas with other learners – collaboration (i.e. Social)
   - ☐ I learn better by self-study and working alone (i.e. Solitary)

9. **What is your favorite subject(s)?**
   - ☐ Pure science – physics, chemistry, Biology
   - ☐ Technology – computer classes and programming
   - ☐ Commercial subjects – accounting, economics and business economics
   - ☐ Languages – English, Afrikaans and home language
   - ☐ Mathematics
   - ☐ Maths Literacy
   - ☐ Agricultural Science
   - ☐ History
   - ☐ Geography
   - ☐ Life orientation
   - ☐ Art and Culture, design subjects
   - ☐ Engineering and Graphics and Design

10. **Give 2 reasons why you like the subject(s)?**
    - Reason 1: .....
      .....
    - Reason 2: .....
      .....

11. **Which school Subject do you find difficult?**
    - ☐ Pure science – physics, chemistry, Biology
    - ☐ Technology – computer classes and programming
    - ☐ Commercial subjects – accounting, economics and business economics

- ☐ Languages – English, Afrikaans and home language
- ☐ Mathematics
- ☐ Maths Literacy
- ☐ Agricultural Science
- ☐ History
- ☐ Geography
- ☐ Life orientation
- ☐ Art and Culture, design subjects
- ☐ Engineering and Graphics and Design

12. Give 2 reasons why you find the subject(s) difficult?

- Reason 1: .....
  .....
- Reason 2: .....
  .....

13. What motivates you to do well at school (Select only 1)?

- ○ Desire to be the best
- ○ Just to Pass
- ○ Competition – I do want my friends or other to do better than me
- ○ Rewards
- ○ Fear of punishment / Failure
- ○ Peer pressure
- ○ Nothing

14. Do you have access to Computer at school (Select only 1)?

- ○ Yes
- ○ No

15. Do you have access to Cell phones at school (Select only 1)?

- ○ Yes
- ○ No

16. Do you have access to Computer at home (Select only 1)?

- ○ Yes
- ○ No

17. Do you have access to Cell phones at home (Select only 1)?

- ○ Yes
- ○ No

18. How good are you at using a computer (Select only 1)?

- ○ Bad
- ○ Basic
- ○ Good
- ○ Excellent

19. Do you play video games (Select only 1)?

- ○ Yes
- ○ No

20. How often to do you play video games (Select only 1)?

- ◯ Once or twice a month
- ◯ Once a week
- ◯ Almost every day

21. How do you like to play games (Select only 1)?

- ◯ Single Player - only me
- ◯ Multi-player – me and others

22. What device do you use to play video games?

- ☐ Computer
- ☐ Smart phone
- ☐ Computer tablet
- ☐ Consoles – PlayStation
- ☐ Video game devices

23. How good are you at playing video games (Select 1)?

- ◯ Not good at all
- ◯ Just a little bit (Basic)
- ◯ Good
- ◯ Excellent

24. What type of games do you like?

- ☐ Board games
- ☐ Card games
- ☐ Word games
- ☐ Video games
- ☐ Simulation games
- ☐ Role -playing games
- ☐ Puzzles

25. What is usually your favorite thing (aspect) about a game?

- ☐ Games that offers rewards (Incentive systems)
- ☐ Games that looks colorful and attractive in design, and it is easy to play. i.e. look and feel (Visual aesthetics)
- ☐ The set activities presented in the game (Game mechanics)
- ☐ Games that tells a Story. i.e. Storyline games (Narrative)
- ☐ Games that plays background sounds whenever a score or next level is achieved (Musical scores)

26. Which elements of a game do you like?

- ☐ Games that are Challenging. i.e. Challenge
- ☐ Games that keep you guessing. i.e. Curiosity
- ☐ Games that has imaginary storyline. i.e. Fantasy
- ☐ Games that you play with others to compete to get a winner. i.e. Competing with others
- ☐ Games that you play with others to exchange ideas and work together. i.e. Collaborative

27. **Do you believe playing video games for learning your subjects can help you to learn better (Select only 1)?**
    - ◯ Yes
    - ◯ No

28. **Do you think that playing video games for educational purposes can help you to improve in subjects that you find difficult (Select only 1)?**
    - ◯ Yes
    - ◯ No

Thank you!! 😊

Teachers Questionnaire

Dear Teachers,

This survey seeks to identify the features and requirements of game-based learning web platform for grade R- 12 learners in South Africa. Game- Based learning (GBL) is the use of games to facilitate the process of learning. Basically, it simply means you as will be using games to learn some of the subjects in the classroom. GBL is useful because it helps Learners persevere, stay engaged, adapt, stay motivated, think out of the box and learn from their mistakes while in the process of learning.

Please answer the following questions which will be exclusively used for data analysis in the research for Scrum requirements engineering for Game-Based learning web platform for Grade R-12 Learners in South Africa. All responses will be treated confidentially.

I, thank you for contributing to the study.

.....

Give your responses to the questions below indicating 'x' inside the ◯ or ☐

Questions:

1. **In which geographical area is your school located in (Select only 1)?**
    - ◯ City
    - ◯ Suburb
    - ◯ Township
    - ◯ Rural

2. **What do you like about teaching in this particular school?**
    - ☐ Teaching & learning facilities
    - ☐ Learners attitude
    - ☐ Sports activities
    - ☐ My fellow teachers

3. **What do you dislike about teaching in this particular school?**
    - ☐ Difficult learners
    - ☐ Performance pressure from school administrators
    - ☐ Lots of paperwork
    - ☐ My fellow teachers
    - ☐ Learners attitude
    - ☐ Poor learners engagement
    - ☐ Learners lack of motivation
    - ☐ Exam time
    - ☐ Lack of proper funding
    - ☐ Lack of parental support
    - ☐ Changing of education trends

4. **What Grade do you teach?** .....

5. **What size is your class(es)?**.....

6. **What subjects do you teach?**

- ☐ Pure science – physics, chemistry, Biology
- ☐ Technology – computer classes and programming
- ☐ Commercial subjects – accounting, economics and business economics
- ☐ Languages – English , Afrikaans and home language
- ☐ Mathematics
- ☐ Maths Literacy
- ☐ Agricultural Science
- ☐ History
- ☐ Geography
- ☐ Life orientation
- ☐ Art and Culture, design subjects
- ☐ Engineering and Graphics and Design

7. **How many years of experience do you have as a teacher?**.....

8. **What is your Race?**

- ○ Black
- ○ Coloured
- ○ White

9. **What is your Gender (Select only 1)?**

- ○ Male
- ○ Female

10. **What is your personality?**

- ☐ Social
- ☐ Outgoing
- ☐ talkative
- ☐ Action-oriented
- ☐ Friendly
- ☐ Shy
- ☐ Quiet
- ☐ Reserved
- ☐ thoughtful

11. **Indicate which of these matches your preferred teaching style?**

- ☐ Authority style - teachers give a lengthy one-way discussion on a pre-assigned topic whilst learners take notes and memories key information.
- ☐ Delegator style – it involves group work- teachers gives a task to learners and observes to promote collaboration and encourage peer to peer learning.
- ☐ Facilitator style - teachers asks learners to question rather than simply having to give answers to them.
- ☐ Demonstrator style – teachers uses a combination of lectures and other forms of teaching such as multimedia presentations and class activities.
- ☐ Hybrid style - teachers incorporates learners personality, preferences as well as their interest into their teaching.

12. **Give 2 reasons why you like teaching style(s)?**
    - Reason 1: .....
      .....
    - Reason 2: .....
      .....

13. **What are some of the challenges that you have with the Learners in the Classrooms?**
    - ☐ Lack of motivation from learners
    - ☐ Poor learners engagement
    - ☐ Difficult learners.
    - ☐ Balancing the diverse learning needs
    - ☐ Forever changing school curriculum
    - ☐ Incomplete homework
    - ☐ Big classrooms – too many learners in one class

14. **Give 2 reasons how you address the above-mentioned challenges?**
    - Reason 1: .....
      .....
    - Reason 2: .....
      .....

15. **How do you motivate the learners in your classrooms?**
    - ☐ Foster a positive learning environment
    - ☐ Build rapport with learners
    - ☐ School/ Classroom rewards
    - ☐ Competition – I do want my friends or other to do better than me
    - ☐ Classroom discussions
    - ☐ Give punishment where necessary

16. **Do you have access to Computer at school (Select only 1)?**
    - ○ Yes
    - ○ No

17. **Do you have access to Cell phones at school (Select only 1)?**
    - ○ Yes
    - ○ No

18. **Do you have access to Computer at school (Select only 1)?**
    - ○ Yes
    - ○ No

19. **Do you have access to Cell phones at school (Select only 1)?**
    - ○ Yes
    - ○ No

20. Do you have access to Computer at home (Select only 1)?

- ○ Yes
- ○ No

21. How good are you in Computer skills (Select only 1)?

- ○ Bad
- ○ Basic
- ○ Good
- ○ Excellent

22. Do you play video games (Select only 1)?

- ○ Yes
- ○ No

23. How often to do you play video games (Select only 1)?

- ○ Once or twice a month
- ○ Once a week
- ○ Almost every day
- ○ Once in a while
- ○ Hardly ever

24. What is your preference when it comes to game playing (Select only 1)?

- ○ Single Player - only me
- ○ Multi-player – me and others

25. What device do you use to play video games?

- ☐ Computer
- ☐ Smart phone
- ☐ Computer tablet
- ☐ Consoles – PlayStation
- ☐ Video game devices
- ☐ None

26. How good are you at playing video games (Select 1)?

- ○ Bad
- ○ Basic
- ○ Good
- ○ Excellent

27. What type of games do you like?

- ☐ Board games
- ☐ Card games
- ☐ Word games
- ☐ Video games
- ☐ Simulation games
- ☐ Role -playing games
- ☐ Puzzles
- ☐ None

28. **Are you aware of Game Based Learning (Select 1)?**

- ◯ Yes
- ◯ No

29. **Have you ever used games as a teaching method in the classrooms (Select 1)?**

- ◯ Yes
- ◯ No

30. **If yes, how was the experience in using games to teach in the classrooms (Select 1)?**

- ◯ Bad
- ◯ Average
- ◯ Good
- ◯ Excellent

31. **If No, Give 2 reasons why you never used games as a teaching method your classrooms?**

- Reason 1: .....
  .....
- Reason 2: .....

32. **Do you believe playing video games for educational purposes can generally help learners to learn better (Select only 1)?**

- ◯ Yes
- ◯ No

33. **Do you think that playing video games for educational purposes can help learners to improve in subjects that you find challenging (Select only 1)?**

- ◯ Yes
- ◯ No

Thank you!! 😊