EXPLORING HOW DIGITAL GAME-BASED LEARNING WITH REWARD SYSTEMS PROMOTES THE DEVELOPMENT OF ACADEMIC SELF-EFFICACY IN GRADE 4 NATURAL SCIENCES AND TECHNOLOGY LEARNERS

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DECLARATION

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I declare that **Exploring how digital game-based learning with reward systems promotes the development of academic self-efficacy in Grade 4 Natural Sciences and Technology learners** is my own work and that all the sources I have used or quoted have been indicated and acknowledged by means of complete references.

I further declare that I submitted the dissertation to originality checking software and that it falls within the accepted requirements for originality.

I further declare that I have not previously submitted this work, or part thereof, for examination at Unisa for another qualification or at any other higher education institution.

2022-01-31

SIGNATURE DATE

DEDICATION

This dissertation is dedicated to my husband Bernard and my children Takunda and Elaine for giving me their family time to work on this study.

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Summary

This study explored the development of academic self-efficacy using Digital Game-Based Learning (DGBL) amongst selected Grade 4 learners. The study adopted a social constructionism paradigm where understandings are cocreated through interpretation. A qualitative explorative and descriptive design was utilized and data from participants was gathered by individual face to face semi-structured interviews, participant observations, participant DGBL journal, research diary and the Adapted Academic Self-Efficacy Scale.

Ten (10) Grade 4 participants were sampled using intensity sampling. The researcher selected participants who manifested sufficient intensity to illuminate “the nature of success” regarding the development of academic self-efficacy through DGBL. A study of existing literature confirms that learners are capable of managing their own learning and mastering different subjects when they have a high academic self-efficacy. The empirical results revealed that participants’ academic self-efficacy improved after using DGBL. The study also uncovered the participants’ meaning of academic self-efficacy through DGBL with reward systems.

Key words

Digital game-based learning (DGBL), academic self-efficacy, rewards systems, sources of self-efficacy, motivation, self- competition in DGBL, academic expectations, adapted academic self-efficacy scale, Natural Sciences and Technology, social cognitive theory.

LIST OF ABBREVIATIONS

CAPS	Curriculum and Assessment Policy Statement
COVID 19	Corona Virus Disease 2019
CSES	Children Self-Efficacy Scale
DBE	Department of Basic Education
DGBL	Digital game-based learning
DoE	Department of Education
ICT	Information and Communication Technology
GDE	Gauteng Department of Education
LTSM	Learning and Teaching Support Materials
MJSES	Morgan-Jinks Student Efficacy Scale
PALS	Patterns of Adaptive Learning Scale
PSES	Perceived Self-Efficacy Scale
SDQ	SELF-Description Scale
SEQ-C	Self-Efficacy questionnaire for children
TIMMS	Trends in International Mathematics and Science study

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CHAPTER 1

INTRODUCTORY ORIENTATION, STATEMENT OF THE PROBLEM, AIM OF THE STUDY AND CONCEPTUALISATION

INTRODUCTION

Creating a competent human being who is able to access information from various sources and use it in a variety of situations is one of several goals in education. Playing video games or other digital games have become a normal part of childhood for many children. A promising strategy for increasing learner engagement in a meaningful way has been thought to come from digital games played on computers and mobile devices. Digital games are described by a rich vocabulary that includes, among others, serious educational games (Cheng, She & Annetta 2014), digital games in digital game-based learning (Liu & Chen 2013:1045; Schaaf 2012), video games to support teaching and learning (Perrotta, Featherstone, Aston & Houghton 2013:5), computer games in educational settings (Chen, Wang & Lin 2015:237) and mobile games (Huizenga, Admiraal, Akkerman & Ten Dam 2009; Venter & De Wet 2016). This study applied the general label of "digital games" as umbrella terminology to include the different games in game-based learning also referred to as digital game-based learning (DGBL).

Kellinger (2017:17) observed that digital games can provide real world contexts which enable learners to make connections, see relationships, think in new ways and see the whole instead of learning isolated or abstract facts which increases the likelihood of skills and knowledge transfer to real world situations. Digital games may bring a school subject such as Natural Sciences and Technology closer to the real world as Loxley, Dawes, Nicholls and Dore (2014:3) are of the opinion that the "intrinsic interest of science is in thinking through and resolving the puzzles which are the ways the world works".

The researcher contended that when Grade 4 learners are led to discover that learning through games can be fun (Campos & Moreira 2016:463-468) and emotionally satisfying, they will work to their full potential. In keeping with the argument on digital games in the previous paragraph, it seemed justified to incorporate digital games to meaningfully and gainfully engage with these learners. This is referred to as DGBL which differs from ordinary games for leisure. Liu and Chen

(2013:1045) supported this notion (incorporation of digital games into learning) by adding that the inclusion of games into education is more effective than the traditional teaching methods in enhancing learning motivation, active participation and concentration among learners. Furthermore, many digital games include a competitive aspect. Jukes, McCain and Crockett (2010:40) relay that the digital game informs the users that if they put in more time to master the game, they will be rewarded with, for example, the next level, a win, a number of stars and/or an indication of the highest score. Since the reward has meaning to them, it would probably encourage them to put in extra effort when playing the game. Therefore, competition in DGBL could be linked to improved learning as it stimulates the interest of learners and increases the efficiency of the learning process (Hwang & Chang 2015:36). As already alluded to by Kellinger (2017:17), digital games are particularly important for science learning because many scientific concepts that are invisible in the real world and therefore not easy to grasp, can be portrayed in the virtual world (Cheng et al. 2015:234).

Improved learning is also supported by the concept of academic self-efficacy. Academic self-efficacy, according to Bandura (1997:37), is a belief or conviction that one can achieve a specific goal or attain a particular outcome on a specific academic task. Research has shown that learners with a strong sense of academic self-efficacy have a greater inherent interest in academic activities, set themselves more challenging goals, and sustain a stronger commitment to them (Byrne, Flood & Griffin 2014:409). As mentioned in the previous paragraph, Hwang and Chang (2015:36) assert that competition in DGBL could be linked to improved learning. Hence, the question arose in the researcher‘s mind how DGBL combined with reward systems to facilitate competition, influenced academic self-efficacy as both appear to improve learning.

The impetus for this study stemmed from the researcher’s observations as an educator that learners tend to cooperate and become excited when they go for computer lessons (an extra period during which they are taught digital literacy on tablets and computers). Even those who are quiet and withdrawn tend to lighten up during computer lessons when they get to play digital games. The researcher pondered whether this excitement of learners could be transferred to DGBL in other subjects. Information and technology is embedded in the daily lives of the present generation of learners (Huizenga et al. 2009:332) and could therefore also be embedded in school subjects. Being trained in Natural Sciences and Technology and in accordance with the assertion of Cheng et al. (2015:234) that digital games are particularly important for science learning, the researcher’s subject choice for this research fell on Natural Sciences and Technology.

Furthermore, since the researcher contended that the exploration of teaching and learning should commence at the basic level of the intermediate phase as "educational pathways are crystallising" in Grades 4 and 5 (Zong, Zhang & Yao 2018:345), the focus of this study was on Grade 4 learners. Approximately a decade ago, Honey and Hilton (2011:21) stated that there was little research about the potential of digital games to improve science achievements. The fact that this status quo has remained more or less the same has motivated research, such as this study.

Zooming out from the sharp focus on Natural Sciences and Technology for Grade 4 learners, the concept of using digital games to support learning activities is not new as studies were already conducted. MoLeNet projects —one of the largest mobile learning projects based in the United Kingdom— conducted research with mobile game devices for teaching and learning from 2007-2008 (Initial phase) (Cochrane 2013:26). The conclusion was that improved peer communication and collaboration lead to the promotion of a healthy degree of competition among the learners (Petley, Parker & Attewell 2013:97). The latter piqued the researcher's interest in exploring the role of competition in DGBL although the researcher preferred to focus on self-competition (Bönte, Procher & Urbig 2018:539) instead of competing with others. Competition with other learners could place learners under pressure and they should compete with themselves rather than with other learners (Kazimoglu, Kiernan, Bacon & MacKinnon 2013:329). Archard (2012:192) elaborates on the assertion of Kazimoglu et al. (2013:329) by stating that although competition between individuals can bring out the best performance, the risk of failure, damage to self-worth and conflict in peer relations remains a possibility. A study by Chen et al. (2015) that compare solitary versus collaborative modes of DGBL in Grade 7 science learners, found no significant difference between the two groups, hence confirming that solitary learning and self-competition (Huizenga et al. 2009:333) improve learning outcomes. According to Bönte et al. (2018:539) self-competition can be viewed as an integral part of life when individuals compete against their own past performances, especially when they are prone to or intrinsically motivated to self-compete. The view of Huizenga et al. (2009:333) is that competition is a factor within individuals that promotes intrinsic motivation. Bönte et al. (2018) and Huizenga et al. (2009) observed that Individuals who are prone to self-compete enhance their intrinsic motivation. Bandura (1994: n.p.) deems motivation as one of the major psychological processes that activates self-efficacy.
Although studies on DGBL are cited above, this research sought to add to the existing body of knowledge of how DGBL with reward systems promoted the development of academic self-efficacy in South African Grade 4 Natural Sciences and Technology learners.

1.2. BACKGROUND TO THE RESEARCH

The background to the study provides information on South African public schools and e-learning; policies and projects pertaining to e-learning that are in place on a national and provincial level; as well as the curriculum for Natural Sciences and Technology. The background is supplemented by international and national studies on DGBL, rewards systems and academic self-efficacy. Furthermore, a discussion on Bandura's self-efficacy theory that anchors the study in a theoretical framework is followed by the conceptual framework. The poor performance of South African learners in science concludes the section showing the significance of the study.

1.2.1 South African Public Schools and e-Learning

In South African public schools, e-learning that involves the use of modern technology like computers and tablets in the teaching and learning process, has hardly begun to become a reality regardless of the important advances in many ways. e-Learning refers to the use of information and communications technology (ICT) to allow access to online learning and teaching resources (Arkorful 2014:397). e-Learning also includes digital games in DGBL. South Africa still lags behind most successful developing nations when it comes to the implementation of e-learning in schools as most provinces are at different levels of ICT integration in education (Meyer & Gent 2016). Despite the South African government's relatively significant expenditure on technology equipment, there seems to be a slow rate of adoption and use of technology in the classroom (Tiba, Condy & Tunjera 2016:1). This could be a result of teachers' teaching experience and attitudes; availability and accessibility of technology; lack of professional and/or technology training; availability of the internet; and poor maintenance of the ICT infrastructure. Observations by Alfreds (2016) suggest that e-learning is not implemented effectively because teaching and learning strategies that incorporate technology, are not well planned as educational managers are misinformed as to what e-learning is actually about. While acknowledging the paucity of information on e-learning, Meyer and Gent (2016:17) confirm the slow implementation of e-learning in Gauteng (a province in South Africa) despite 80% of Gauteng schools having computer labs in 2010 that provide learners access to one lesson per week. In 2014, learners' access to computers was mostly limited to quintile 3 and higher schools (Meyer & Gent 2016:17). South African schools are categorised into five groups or quintiles ranging from schools in the poorest communities (quintile 1 schools) to schools in the wealthiest communities (quintile 5 schools) (HSRC Annual report 2009/2010:49). This study was carried out in a Gauteng public primary

quintile 5 school that has a computer lab with tablets and computers with digital games for DGBL. However, the classrooms in this school are not equipped with computers to integrate DGBL during Natural Sciences and Technology lessons in the classroom.

1.2.2 Policies and Projects pertaining to e-Learning

Although the slow implementation of e-learning is mentioned in the previous paragraph, policies, projects, an action plan and a commission on national and/or provincial levels are already in place as outlined below.

- **National level**

The following policies, action plan, project and commission are relevant to this study on a national level:

  - **White Paper 7 on e-Education: Transforming Learning and Teaching through Information and Communication Technologies (ICTs)** (Department of Education [DoE] 2004) hereafter, *e-Education White Paper*

The South African education and training system like most parts of the world had to respond to the pressures and challenges posed by the information revolution. The e-Education White Paper (DoE 2004) is the first attempt to include ICT in the curriculum. The introduction of ICT represents an important part of the government‘s strategy to improve the quality of learning and teaching across the education and training system (DoE 2004:19). The e-Education White Paper’s objective is to build digital and information literacy so that all learners become confident and competent in using technology to contribute to an innovative and developing South African society. Although the e-Education White Paper (DoE 2004) does not mention tablets or digital games in particular, it describes e-learning as flexible learning that uses ICT resources, tools and applications; focusing on accessing information; together with interaction among teachers, learners and the online environment; that may involve, among others, software and other media (DoE 2004:15). This exposition supported the researcher’s notion that the study was in line with the e-Education White Paper (DoE 2004) as tablets and games are resources, tools and applications that are part of e-learning.

  - **National Draft Policy for the Provision and Management of Learning and Teaching Support Material (LTSM)** (Department of Basic Education [DBE] 2014)

The National Draft Policy for the Provision and Management of LTSM was introduced to ensure that all injustices and inequalities of the past with regard to learner support are addressed. The policy ensures that the production and selection of quality LTSM are made available to all learners in public schools. According to this policy (albeit in draft format), learners and teachers should be

provided with curriculum resources that are current and relevant (DBE 2014:7). The policy aims at supporting learners in the acquisition of information literacy skills that include digital literacy in various formats such as e-Books. The digital games in DGBL that are included in this study, are considered part of digital literacy by the researcher.

- **Action Plan to 2019: Towards the Realisation of Schooling 2030** (DBE 2015)

The Action Plan to 2019 is informed by the National Development Plan that guides the nation towards 2030 (DBE 2015:8). The Action Plan to 2019 states that ICT enhances the teaching and learning experience in classrooms (DBE 2015:17). In fact, the Action Plan to 2019 considers education without ICT as an "incomplete education" (DBE 2015:17).

- **Thutong South African Education Portal** (http://www.thutong.doe.gov.za/)

The Thutong South African Education Portal is a database or store of shared resources that includes lessons plans, worksheets, examinations and policy documents. It has a set of facilities that encourages the creation and sharing processes of educational materials (Thutong South African Educational Portal).

- **Presidential National Commission on Information Society and Development** (Department of Communications 2002)

The Presidential National Commission on Information Society and Development implemented the Apex Project 3 to increase the usage of ICT in schools through e-education in order to contribute to the advancement of the Information Society (DoE 2004:10). The main sub-project of the Apex Project 3 aims to improve the wireless connectivity of Dinaledi schools. (Dinaledi schools receive a grant provided that certain targets are met in terms of Mathematics and Physical Science.) The Dinaledi schools were selected as the hub for the government's Apex Project 3 which is concerned with ICT interventions that provide cheap platforms (Apex Priorities 2008).

- **Provincial level**

The following projects are relevant to this study on a provincial level:

- **Khanya Technology in Education Project** (Western Cape Department of Education 2011)

The Khanya Project is aimed at removing the digital divide between rich and poor schools to empower teachers, learners and the community in the use of technology by providing appropriate technology to all schools in the Western Cape. The project promotes learning and maximises teacher capacity by integrating the use of appropriate and available technology into the curriculum delivery process (Western Cape Department of Education 2011). The project focuses on one key strategic objective in the e-Education White Paper (DoE 2004:29), namely access to technology.

- **Gauteng Paperless** (Gauteng Department of Education [GDE] 2016)

The *Schools of the Future Paperless Classroom* rollout programme in Gauteng increased the number of Full ICT Schools in which e-content including e-Books are preloaded onto ICT devices such as teacher laptops, learner tablets and Smart Boards (GDE 2016:5;9).

1.2.3 Curriculum for Natural Sciences and Technology

The researcher mentioned Natural Sciences and Technology as her subject of choice (see 1.1) for DGBL implementation. The curriculum in South African public schools is known as the Curriculum and Assessment Policy Statement (CAPS). The CAPS is a policy document that was adapted by the Department of Basic Education to ensure that all the learners acquire and apply knowledge and skills in ways that are meaningful to their own lives (DBE 2011a:4). This policy places emphasis on the achievement levels of learners as well as what is expected from learners after completing their education. At Grade 4 level, the CAPS content together with diverse methods of teaching and learning Natural Sciences and Technology (which include DGBL in the researcher's opinion), were selected to sustain enjoyment and inquisitiveness about the world (DBE 2011a:8; DBE 2011b:4). Table 1.1 contains the topics of Grade 4 Natural Sciences and Technology in the CAPS (DBE 2011a:16-30).

Grade 4 Topics in Natural Sciences and Technology	
Grade 4 Term 1	Living and non-living things
	Structure of plants and animals
	What plants need to grow
	Habitats of animals
	Structures for animal shelters
Grade 4 Term 2	Materials around us
	Solid materials
	Strengthening materials
	Strong frame structures
Grade 4 Term 3	Energy and energy transfer
	Energy around us
	Movement and energy in a system
	Energy and sound
Grade 4 Term 4	Planet earth
	The sun
	The earth and the sun
	The moon
	Rocket systems

Table 1.1: Topics of Grade 4 Natural Sciences and Technology

In support of the CAPS and to help learners understand difficult scientific concepts without losing interest in the subject, the researcher contended that DGBL can be incorporated into the teaching and learning of science. This argument is supported by Papastergiou (2009) cited in Liu and Chen (2013:1045) who states that DGBL enables learners to participate actively with greater interest which leaves a deeper impression than conventional teaching methods.

1.2.4 International and National Studies on DGBL, Rewards Systems and Academic Self-efficacy

The following concise discussion of DGBL shows its wide application in various educational settings and contexts with reference to rewards systems and academic self-efficacy in some instances.

On the international front Yang, Quadir and Chen (2019:374) remark that “DGBL is widely accepted as one of the formal learning media, but not all learners benefit from its support”. However, due to the diverse learning activities as well as the effectiveness of DGBL, teachers use it in various subjects because learners enjoy learning through gameplay (Yang et al. 2019:375).

DGBL according to Whitton (2013:18) provides a safe environment where learners can learn from their own mistakes. Several researchers such as Maciuszek, Ladhoff and Martens; Saridaki and Mourlas; and Shelton, Satwicz and Caswell in Felicia (2013) underscore the motivational aspect of rewards in digital games. The competitive aspect of digital games may give rise to the experience of success in the learning process when learners’ attempts at higher scores motivate them to put in extra effort. As the learners play and master the games, they would probably judge their competences. Academic self-efficacy can be increased as result of the experience of success as established by Zhang (2014:48) who finds that academic self-efficacy is associated with exceptional assessment performance and goal achievement. A similar observation was made by Byrne et al. (2014:409) who find that a robust sense of academic self-efficacy makes leaners develop an interest in their educational activities that motivate them to set challenging goals for themselves to which they are committed. A study by Meluso, Zheng, Spires and Lester (2012:501) finds a significant increase in the science self-efficacy of 5th graders after playing a digital mathematical game. In another study regarding science self-efficacy, Hung, Sun and Yu (2015:185) find that anxiety associated with challenging games may be reduced when the learners “engage in tasks actively and with a feeling of enjoyment”. Since self-efficacy is domain-specific and task-specific, it is more accurate to refer to “science self-efficacy” or “science learning self-efficacy” (Cheng, Tsai & Liang 2019:3). However, the researcher applied the umbrella term of academic self-efficacy to depict the learner’s belief or conviction that he/she can achieve a specific goal or attain a particular outcome on a specific academic task (Bandura 1997:37).

A limited amount of research on DGBL has been conducted in South Africa. A study by De Kock (2013) on DGBL and library instruction, finds that DGBL aids in learner empowerment, improved knowledge and increased motivation and engagement. Another South African study on DGBL by Titus (2016) applied digital games in Physical Education studies. The conclusion of the study is that cross-cultural interaction and relationships among peers improve as a result of DGBL. Venter and De Wet (2016) investigated the perceived enjoyment of mobile mathematical learning games. The study found that perceived enjoyment is stimulated by interest, fantasy, reward systems and

clear goals of mobile learning games. The rewards that the participants in this study earned, such as bullets, pets or keys to unlock something (Venter & De Wet 2016:117), tie in with the researcher's conception of self-competition. A study by Dreyer (2017:85) establishes that DGBL facilitates learning in a positive way although traditional methods of learning are equally effective. The latter is in contrast to Liu and Chen's (2013:1045) assertion —stated in 1.1— that the inclusion of games into education is more effective than traditional teaching methods. However, Dreyer's (2017) study involved tertiary education participants whereas Liu and Chen's (2013) study involved primary school learners. The researcher has already stated (also in 1.1) that ICT is embedded in the daily lives of the present generation of learners leading to the researcher's speculation that more mature learners could perhaps be less susceptible to DGBL at the time of Dreyer's study. However, Huizenga et al. (2009:333) are wary of conclusive results which claim that DGBL is more effective. Chen et al. (2015:238) show that recent research suggests mixed results.

1.2.5 Bandura's Self-Efficacy Theory as Theoretical Framework

Bandura (1977:194) defines self-efficacy as the belief, or confidence, that one can effectively execute a behaviour required to produce an outcome. Self-efficacy is part of social cognitive theory that is concerned with opinions, how they affect processes and how they can be improved for social and individual change (Bandura 2012:13). The focus of this study was on individual change in the development of academic self-efficacy in Grade 4 Natural Sciences and Technology learners. Bandura's self-efficacy theory and in particular the four main sources of self-efficacy beliefs, namely (i) mastery experiences; (ii) vicarious experiences by social models; (iii) social persuasion i.e. persuasion by others; and (iv) somatic and emotional states (Bandura 1994), formed the basis of this study. Academic self-efficacy, as one of the main areas of self-efficacy, concerns the perceived capability to fulfill academic demands. Academic self-efficacy comprises "children's beliefs in their efficacy to manage their own learning activities; to master different academic subjects; and to fulfill personal, parental, and teachers' academic expectations" (Bandura, Pastorelli, Barbaranelli & Caprara 1999:259). Bandura's theory provided a framework, shown in Figure 1.1, in exploring how DGBL influenced academic self-efficacy in Grade 4 Natural Sciences and Technology learners.

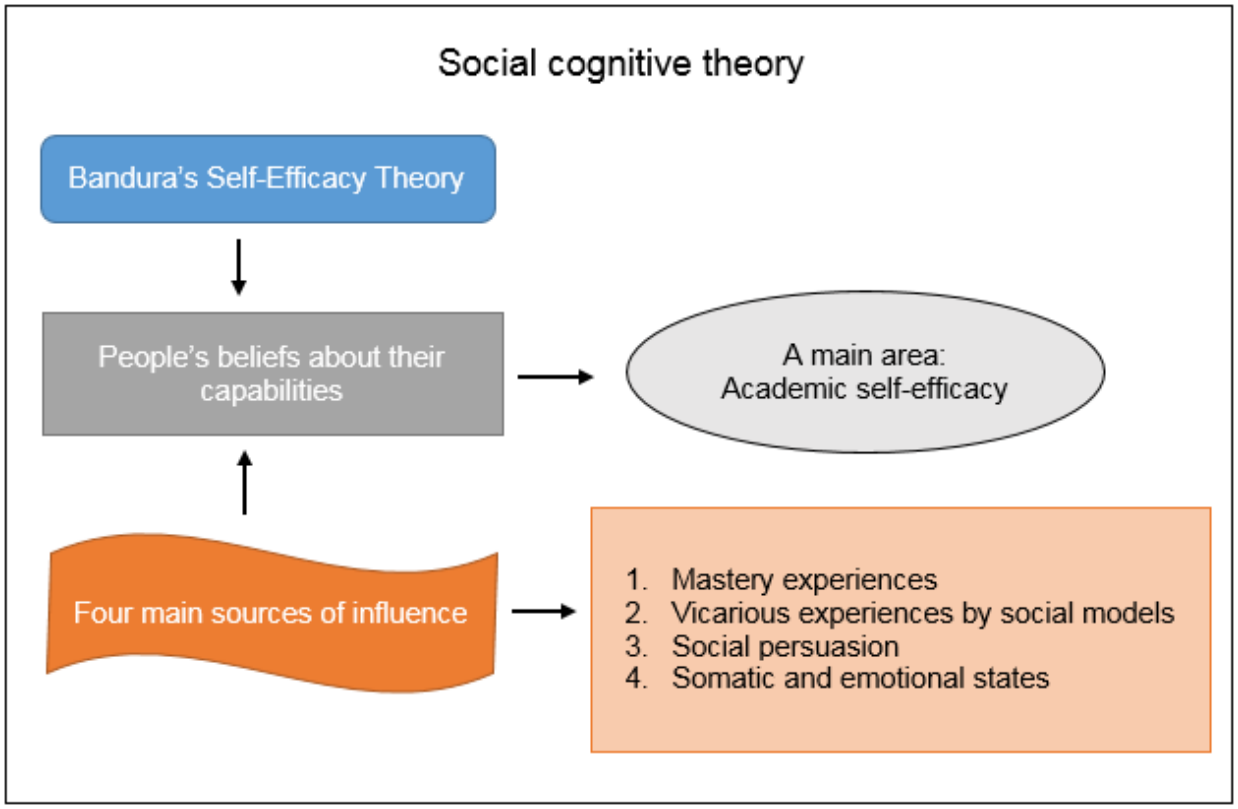


Figure 1.1: Theoretical framework according to Bandura's Self-Efficacy Theory

The higher the level of self-efficacy, the more an individual believes he or she can execute the behaviour necessary to obtain a particular outcome. The way people think, feel and are motivated to behave in certain ways, is determined by self-efficacy beliefs which play a role in how goals and challenges are approached. Bandura's self-efficacy theory (1994) stresses the critical role of self-beliefs in human thought, motivation and behaviour. People will generally only attempt things they believe they can accomplish. However, those with a strong self-efficacy believe they can accomplish even difficult tasks that are more challenging. They view a challenge as something that has to be mastered or overcome rather than threats to be avoided (Bandura 1994: n.p).

Bandura (1994: n.p.) maintains that self-efficacy beliefs have shown that academic enthusiasm in *mastery experiences* is influenced by perseverance, effort exerted and the choice of activities, for example, suitable digital games in the researcher's opinion. Bandura (1999:28) emphasises that as long as people believe that they are able to produce desired effects by their actions, they will persevere in the face of problems to achieve success. Self-efficacy focuses on a person's ability to achieve a particular task and it is also concerned with judgements of personal

competence. A strong sense of self-efficacy enhances human accomplishments. Bandura (1993:118) in his review of self-efficacy establishes that most causes of action are originally formed in thought. People with a high level of self-efficacy, envision success scenarios and this will in turn provide positive guides for performance. Those with poor self-efficacy, visualise failure scenarios as they dwell on how things will not work and go wrong.

At Grade 4 level, learners are expected to learn more independently and assume responsibility for their actions which requires a great deal of self-efficacy. In Natural Sciences and Technology, they are assigned short research projects as outlined by the CAPS in learning the significance of evidence-based inquiry to nurture scientific thinking (DBE 2011a:8). Learners are expected to set their own realistic goals that need to be accomplished as well as independently gather information on the internet and in textbooks which require self-efficacy. The development of self-efficacy in young children should be promoted as it could influence experiences as they grow older. Against such a background, DGBL was considered coupled with teachers who are also required to experiment with new ideas and techniques (DBE 2011b:11). Bandura (1994: n.p.) asserts that the most effective way of obtaining a strong sense of efficacy is through mastery experiences, for example, when leaners master digital games. During play, success builds a strong belief in their sense of self-efficacy. They pursue challenges that provide them with chances to increase their knowledge and competences (Bandura 1993:120). However, experiencing failure is equally important in that it builds resilience when failures or setbacks are considered as learning opportunities. Snow (2016:6) states that through DGBL learners can test and construct skills in an environment that is safe, when “failing” is regarded as a chance to level up and improve.

Bandura (1993:121) states that the people with whom individuals compare themselves, influences how they judge their ability. *Vicarious* (or mediated) *experiences* occur when learners observe others who are successful at performing different tasks. With regard to learners in this study, the researcher proposed that they would set goals according to their capabilities while playing digital games with their peers in class. When they see their peers achieving, for example, higher scores or shorter times in the game, they would most probably strive to reach a similar, if not higher, score and/or shorter time. Competing against others was not the focus of the study, although the researcher considered Bandura’s vicarious experiences as a regular occurrence in the classroom during DGBL. Bandura (1977:197) supports the researcher’s notion by maintaining that observing others who perform activities successful, does indeed produce greater behaviour improvements.

When individuals are convinced that they can attain, they are more likely to do the task. Being *persuaded by others* that one has what it takes to succeed, is a way of strengthening self-efficacy. Bandura (1994: n.p) states that people who are verbally persuaded that they have the competences to master given activities, will try hard to succeed. Positive feedback enhances self-efficacy while negative feedback generally decreases self-efficacy. When learners are supported and belief in them is expressed, they feel empowered and begin to set higher goals for themselves. Realistic encouragement is a very powerful tool for increasing self-efficacy beliefs in others. The researcher maintained that Grade 4 learners were capable of engaging in goals if they felt validated and empowered.

Individuals use their *somatic and emotional states* or bodily feelings and moods when formulating their self-efficacy beliefs regarding certain behaviour. For example, positive mood improves self-efficacy while bad mood reduces it. Bandura (1999:30) asserts that people rely partly on their somatic and emotional states in judging their abilities. On the one hand, people interpret their stress reactions and tension as signs of vulnerability to poor performance. On the other hand, positive emotions boost confidence in their skills. Therefore, individuals' state of mind influence how they judge their self-efficacy.

The four sources of self-efficacy beliefs (mastery experiences; vicarious experiences by social models; social persuasion; and somatic and emotional states) directly influence several behavioural outcomes.

1.2.6 **Conceptual Framework**

The central concepts to this study are conceptualised below.

(a) Digital game-based learning

Digital game-based learning (or DGBL) is conceptualised in this study as a form of learning in which learners acquire knowledge by playing digital games on a digital device. The game activities are designed to maintain balance between the subject content and game play by providing descriptive feedback to ultimately facilitate recall and application of attained knowledge to real world situations. The game activities are in the form of lessons that are competitive and involve challenges which assist learners to gain a sense of achievement while constructing a higher level of knowledge and having fun at the same time.

(b) Self-competition in DGBL

Self-competition in DGBL is a learning activity using game reward systems that allow learners to exploit their real capabilities as they strive to get the highest possible scores, positive feedback, leaderboards, and points by outdoing themselves in a game. It provides motivation, generate excitement as well as increase attention of those playing.

(c) Academic self-efficacy

Academic self-efficacy refers to an individual's belief or sense of competence in his or her abilities to organise and perform an educational task successfully.

1.2.7 Current Status of the Problem and Significance of the Study

Science and Technology and innovation have become the forces that drive economic growth and competitiveness with the potential of improving the quality of life (Honey & Hilton 2011:5; Juan & Visser 2017:1). Conversely, according to various researchers cited by Anagnostou and Pappa (2013:1), there is consensus that poor performance in science continues to be a global challenge as learners' interests in science topics is gradually declining in most countries.

Despite the global decline in science performance, South Africa remains one of the lower performing countries in comparison to other countries at similar levels of development. This was reflected by the Trends in International Mathematics and Science Study (TIMSS), which showed that South Africa was one of the lower performing countries in Mathematics and Science when compared to other participating countries (Reddy, Visser, Winnaar, Arends, Juan, Prinsloo & Isdale 2016:5). This lack of attainment in science subjects is disturbing considering the growing need for Science and Technology professionals in the labour force coupled with the fact that Science and Technology is key to South Africa's future. To promote positive attitudes towards science, the experiences which stimulate learners' conceptual development must be rewarding both intellectually and emotionally (Loxley et al. 2014:8). Therefore, the researcher asserted that this can be achieved by incorporating DGBL albeit in a small-scale research study.

South Africa's poor achievement in TIMSS is a result of the public education system that is still operating as a two-way system which is characterised by unequal performance and resource donations (DBE 2014:7). It is the result of a legacy that was created by segregation during the apartheid era. The difference in the socio-economic status of parents, wealth, geographic location, infrastructure and language makes it difficult for education to be on the same level in all

South African schools. Generally, learners who performs well in science are those at independent schools where they have resources like computers and parents supporting learners in their academic endeavours (Letaba 2017). Those in the no-fee public schools, characterised by large classes, access issues, infrastructure shortages and lack of skilled instructors, are the worst affected. Some parents of these affected learners cannot speak English, therefore preventing full or productive parental involvement. For example, when their children are taught in a language that they cannot speak, they cannot assist them with homework. Furthermore, Spaull (2013:3) also confirms that a large number of South African learners are operating below the standard set by the curriculum.

The researcher's envisioned contribution through this study was to not only to create an engaging and fun-filled learning experience in a Gauteng Grade 4 Natural Sciences and Technology classroom, but also to contribute to the development of these learners' academic self-efficacy through the application of DGBL. This small-scale research study could provide a portal for similar larger research projects to stimulate interest and improve achievements in science in South Africa.

1.3 PROBLEM STATEMENT

South Africa is one of the lower performing countries in Mathematics and Science when compared to other countries at similar levels of development (Reddy et al. 2016:5). There is need to improve Science learning in South Africa and this needs to be done starting from lower grades. Grade 4 Natural Sciences and Technology learners are expected to learn more independently and acquire skills like problem solving and analytic skills. These skills can be influenced by learning activities like DGBL which may lead to improved learning. Improved learning is also supported by the concept of academic self-efficacy. Academic self-efficacy is linked with being the best in achieving goals and having an innate interest in doing things (Wang and Neihart 2015:65). Digital games are being used in schools for educational purposes and can provide learners with a playful and familiar opportunity to engage with Natural Sciences and Technology content. It is therefore, necessary to explore how DGBL with reward systems promote the development of academic self-efficacy in Grade 4 Natural Sciences and Technology learners?

The following research sub-questions assisted in answering the problem statement:

- How is academic self-efficacy deconstructed and measured?

- Which aspects or logistics are involved in the availability; terms and conditions; and acquisition and affordability of educational digital games?
- Which educational digital games with reward systems support the curriculum of Grade 4 Natural Sciences and Technology?
- How do reward systems in game-based learning contribute to the development of academic self-efficacy?

1.4 AIM AND OBJECTIVES

The aim of the study was to explore how DGBL with reward systems promoted the development of academic self-efficacy in Grade 4 Natural Sciences and Technology learners. In order to attain the aim and to find answers for the research sub-questions, the researcher set the following objectives:

- Deconstruct academic self-efficacy and related measures by means of a literature study
- Conduct a literature study on the aspects or logistics involved in the availability; terms and conditions; and acquisition and affordability of educational digital games
- Match educational digital games with reward systems to the curriculum of Grade 4 Natural Sciences and Technology
- Acquire and download the educational digital games
- Determine how digital game-based learning with rewards systems support the curriculum of Grade 4 Natural Sciences and Technology.
- Examine how reward systems in digital game-based learning contribute to the development of academic self-efficacy in Grade 4 learners.
- Conduct an empirical investigation in a Grade 4 Natural Sciences and Technology classroom at a primary school in Gauteng by means of a case study strategy.

1.5 RESEARCH METHODOLOGY

According to Ling and Ling (2017:24) the research methodology involves decisions about the participants, the data to be collected, data collection methods and tools, the way the data will be analysed and the overall approach to be adopted. Newby (2014:53) adds that research

methodology has to do with the use of suitable rules of investigation as well as the gathering of tools for research. Figure 1.2 provides a bird's-eye view of the study's research methodology.

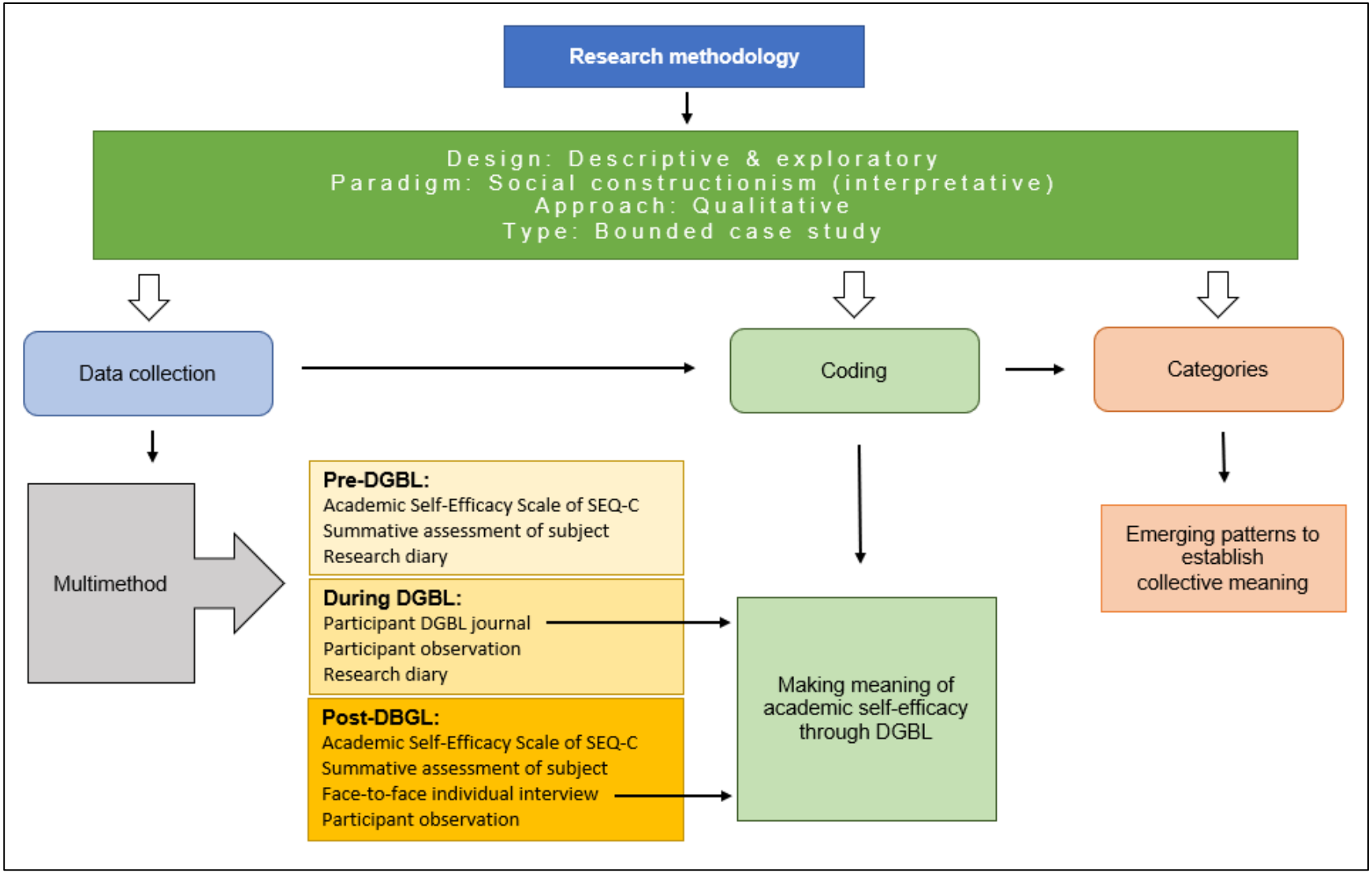


Figure 1.2: Schematic exposition of the research methodology

1.5.1 Research Design

The research design of the study was mainly descriptive to accurately portray all the factors, captured in Figure 1.2 and Table 1.2, that were relevant to the problem statement. Part of the description involved the natural world, namely the participants playing digital games in the computer lab at school. The design was also exploratory to uncover aspects or logistics that were involved in educational digital games. The research paradigm, approach and type are outlined in the subsections below.

(a) Research paradigm

The researcher assumed the ontology (a theory of existence) of multiple realities. According to Owen (1992:389) the search for knowledge or "truth" can be traced back to, among others, the German philosopher, Martin Heidegger, who used the Greek word *aletheia* which means disclosure of meaning. Owen (1992:389) considers truth or *aletheia* as a never-ending series of uncoverings implying that there is not one or absolute truth. The researcher applied social constructionism of the founding theorist, Gergen (1985), to uncover the participants' meaning making of academic self-efficacy through DGBL. Social constructionism entails the collective generation of meaning which suggests some kind of interaction between the inquirer and the knowable when these understandings are created (Lee 2012:405). The subjectivist epistemology of social constructionism in which understandings are cocreated through interpretation, is inevitably linked to the context of the 21st century technology revolution and required skills as well as e-learning in South African public schools (see 1.2.1).

(b) Research approach

The research approach was qualitative. Creswell (2014:50) calls for qualitative research if research related to the topic is fairly limited. The researcher has already indicated in 1.2.4 that a limited amount of research on DGBL has been conducted in South Africa of which none covered the current problem statement (see 1.3).

(c) Research type

The design was a case study to provide an in-depth analysis of how DGBL influenced the construction of meaning of academic self-efficacy. The number of participants was too small for a case series. Merriam (1998) cited in Yazan (2015:139) defines case study research as a unit around which there are boundaries such as a person, a programme (DGBL in this instance), a group or a specific policy. In this research, the single-case was bounded by time and activity (see

Table 1.2) and information was collected by using a variety of data collection instruments (see Figure 1.2). All these aspects are detailed in the next section on research methods.

1.5.2 Research Methods

Research methods comprise the procedures, tools and techniques in gathering and analysing data. Participant selection, data collection, data analysis, trustworthiness and ethical considerations are outlined in the subsections below.

(a) Participant selection

As suggested by Patton (1990:169), the authority on qualitative inquiry, a small number of information-rich participants were purposefully selected. Information-rich cases are those that can provide the most information about the aim of the research (see 1.4). In this study, ten male and female Grade 4 participants of one Natural Sciences and Technology class were sampled using intensity sampling. The researcher selected participants who manifested sufficient intensity to illuminate the "nature of success" (Patton 1990:171) regarding the development of academic self-efficacy through DGBL. Since intensity sampling requires "some prior information and considerable judgment" (Patton 1991:172), the researcher employed the Adapted Academic Self-Efficacy Scale, a subscale of the Self-Efficacy Questionnaire for Children (SEQ-C) (Muris 2001), as well as the subject's summative assessment before the DGBL for participant selection. Table 1.2 sheds light on the use of instruments in the participant selection.

(b) Data collection

The discussion highlights three aspects in data collection, namely the data collection instruments, the phases of the data collection and the basis for inclusion of the instruments as also shown in Table 1.2.

The data collection instruments consisted of the Adapted Academic Self-Efficacy Scale, a subscale of the SEQ-C (Muris 2001); the summative assessment of Grade 4 Natural Sciences and Technology; a research dairy with process notes and reflection; a participant DGBL journal; participant observation according to an observation schedule and impromptu; and an individual face-to-face interview according to an interview schedule. The data was collected in three phases before, during and after the DGBL. The data collection instruments served to select participants, to explore the aspects or logistics that were involved in educational digital games and to provide answers to the problem statement and research sub-questions (see 1.3).

Table 1.2 1: Topics of Grade 4 Natural Sciences and Technology and data collection

<table>
<tr><th colspan="4">Data collection schedule according to topics of Grade 4 Natural Sciences and Technology and three phases of DGBL</th></tr>
<tr><th colspan="2">Topics</th><th>Data collection instruments</th><th>Phase 1: Pre-DGBL</th></tr>
<tr><td rowspan="5">Grade 4 Term 1</td><td>Living and non-living things</td><td rowspan="5">• Academic Self-Efficacy Scale of the SEQ-C
• Summative assessment of Natural Sciences and Technology
• Research diary (process notes and reflection)</td><td rowspan="4">Baseline assessment for participant selection</td></tr>
<tr><td>Structure of plants and animals</td></tr>
<tr><td>What plants need to grow</td></tr>
<tr><td>Habitats of animals</td></tr>
<tr><td>Structures for animal shelters</td><td>To inform sub-research question</td></tr>
<tr><td rowspan="4">Grade 4 Term 2</td><td>Materials around us</td><td rowspan="8">• Participant DGBL Journal
• Participant observation
• Research diary (process notes and reflection)</td><td>Phase 2: During DBGL</td></tr>
<tr><td>Solid materials</td><td rowspan="7">To inform problem statement</td></tr>
<tr><td>Strengthening materials</td></tr>
<tr><td>Strong frame structures</td></tr>
<tr><td rowspan="4">Grade 4 Term 3</td><td>Energy and energy transfer</td></tr>
<tr><td>Energy around us</td></tr>
<tr><td>Movement and energy in a system</td></tr>
<tr><td>Energy and sound</td></tr>
<tr><td rowspan="5">Grade 4 Term 4</td><td>Planet earth</td><td rowspan="5">• Academic Self-efficacy subscale of the SEQ-C
• Summative assessment of Natural Sciences and Technology (Terms 2 & 3)
• Face-to-face individual interview
• Participant observation</td><td>Phase 3: Post-DGBL</td></tr>
<tr><td>The sun</td><td rowspan="3">Compare to baseline assessment for participant selection</td></tr>
<tr><td>The earth and the sun</td></tr>
<tr><td>The moon</td></tr>
<tr><td>Rocket systems</td><td>To inform problem statement</td></tr>
</table>

(c) Data analysis

The analysis of the data is outlined below according to each of the instruments.

- **Adapted Academic Self-Efficacy Scale, a subscale of the SEQ-C** (Muris 2001)

A total academic self-efficacy score was obtained by summing across all items ranging from 8 (low academic self-efficacy score) to 40 (high academic self-efficacy score) (Suldo & Shaffer 2007:344). The pre-DBGL score of the participant was compared to the post-DGBL score to determine whether there was an increase in the academic self-efficacy score.

- **Summative assessment of Grade 4 Natural Sciences and Technology**

The summative assessment of each participant in Term 1 was compared to the average of the participant's summative assessment in Terms 2 and 3.

- **Research diary with process notes and reflection**

The research diary was incorporated into the exploration and description of the aspects or logistics that were involved in educational digital games.

- **Participant observation**

Participant observation served two purposes. Firstly, impromptu observation of the participants during the DGBL was captured in the research diary and either incorporated into the exploration and description of the aspects or logistics of DGBL or compared to the participant DGBL journal to further their experiences and beliefs. Secondly, participant observation was added to the verbatim transcriptions of the individual face-to-face interviews in preparation for coding.

- **Participant DGBL journal and individual face-to-face interviews**

A thematic analysis to organise, code (process, descriptive, focused) and categorise the data (Saldaña 2016) was done using the participants' encounters, conceptualisations, emotions and deliberations in the journal (Hayman, Wilkes & Jackson 2012:27) as well as the verbatim transcribed interviews. Covid 19 protocols such as wearing of masks were observed.

(d) Trustworthiness

The credibility of the study is enhanced by triangulation (see Table 1.2) through multi-method data collection. Intercoder agreement (Creswell 2014:252) between the researcher and supervisor was reached after revisiting the data repeatedly. The subjective analysis of data was curbed to a certain extent by bracketing although the researcher could bring bias to the study being a teacher at the particular school where the research was conducted. Member checking was used to determine the accuracy of the findings by taking the categories back to the participants (Creswell 2014:251) albeit on a modified level that the participants could understand.

(e) Ethical considerations

Research ethics are focused on what is morally proper and improper when engaging with participants (McMillan & Schumacher 2014:129). Most educational research deals with human beings, therefore the researcher is ethically responsible for protecting the rights and welfare of the participants (McMillan & Schumacher 2014:23).

The researcher complied with all the ethical requirements by obtaining clearance, permission, consent and assent from the Research Ethics Committee of the University of South Africa, the Department of Education Johannesburg East District 9, the school principal and governing body, the participants and their parents. Voluntary participation at any moment of the DGBL research, confidentiality regarding participants and the research site as well as secure data storage were also maintained.

1.6 CHAPTER DIVISION

The study consists of five chapters as indicated below:

- **Chapter 1**

Chapter 1 presents the introduction to the study (see the conclusion below).

- **Chapter 2**

Chapter 2 comprises a literature study to deconstruct academic self-efficacy and related measures. The literature is also perused to explore information about the aspects or logistics involved in the availability; terms and conditions; and acquisition and affordability of educational digital games.

- **Chapter 3**

Chapter 3 provides in-depth details of the research methods, participant selection, data collection, data analysis, trustworthiness and ethical considerations.

- **Chapter 4**

Chapter 4 presents the results and discusses the findings of the empirical investigation in detail.

- **Chapter 5**

In Chapter 5 a summary of the literature findings and the empirical investigation is presented in relation to the problem statement. This is followed by a conclusion, discussion of limitations of the current study and recommendations for further studies.

1.7 SUMMARY

Figure 1.3 summarises in a simplified manner the core aspects that lead to the problem statement. The point of departure in Figure 1.3 is that digital games can provide real world contexts which enable learners to make connections, see relationships and think in new ways. Since many digital games include a competitive aspect, learners who put in more effort to master the game, are rewarded. Competition in DGBL could be linked to improved learning as it stimulates the interest of learners and increases the efficiency of the learning process. Academic self-efficacy which can be increased by experiencing success, also relates to improved learning and was included in the research question in Figure 1.3.

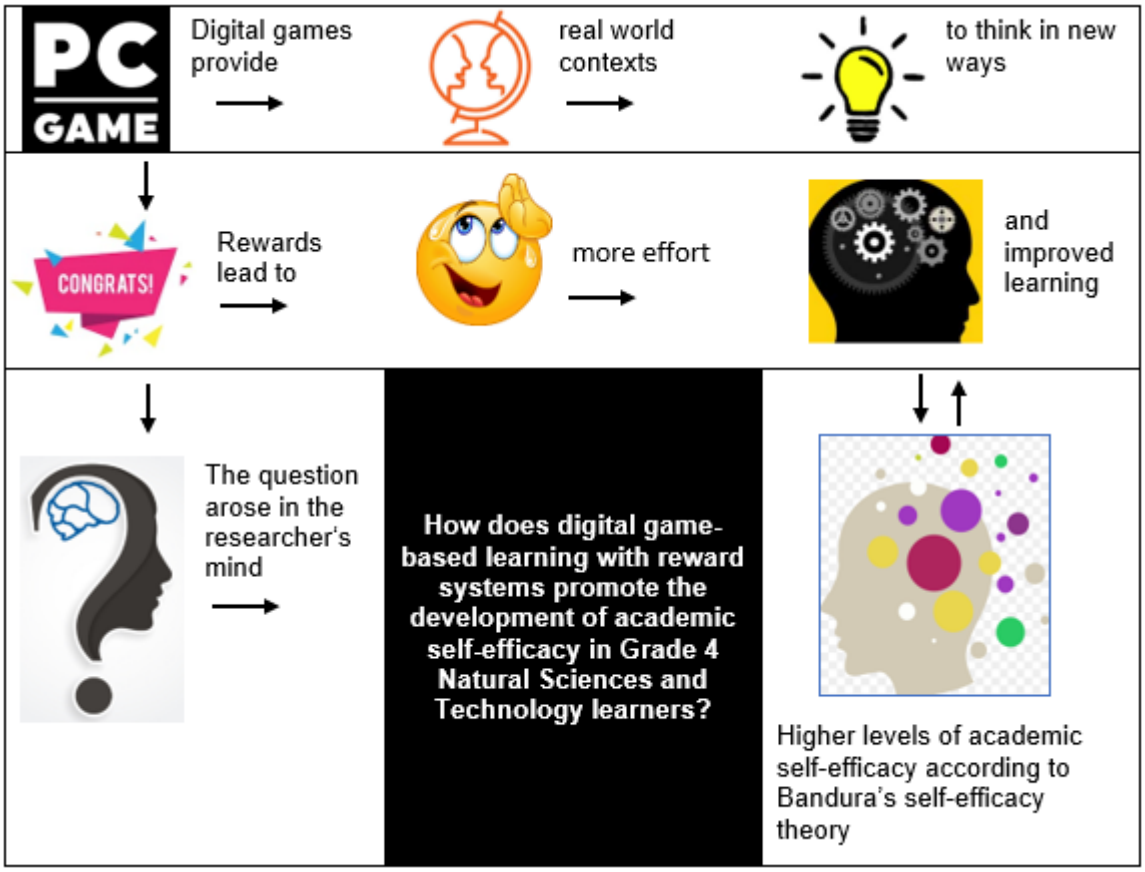


Figure 1.3: Simplistic depiction of the study's core elements

The chapter also contextualised the study by providing background to the research; the theoretical and conceptual frameworks; the current status of the problem as well as the significance of the study. Furthermore, the problem statement and research sub-questions were formulated, together with the aim and objectives of the study. These were followed by the research methodology to undertake a sound empirical investigation in adding to the body of knowledge of how DGBL with reward systems promoted the development of academic self-efficacy in South African Grade 4 Natural Sciences and Technology learners.

CHAPTER 2

DIGITAL GAME-BASED LEARNING AND ACADEMIC SELF-EFFICACY – PERSPECTIVES FROM THE LITERATURE AND GAME COLLECTION

2.1 INTRODUCTION

The researcher found herself in unchartered waters pertaining to her research topic when a search of the keywords “digital game-based learning; science; South Africa” did not yield any results in the extensive databases of *EBSCOhost Education Source*, *Taylor and Francis Online Journals* and the *Unisa Institutional Repository*. Therefore, the chapter commences with reviewing the literature on the directives and dilemmas in DGBL as the researcher could not find specific DBE curriculum-supported games or guidelines for Grade 4 Natural Sciences and Technology in South Africa. Contrary to the scanty South African literature, international research is voluminous, recent and elaborately enhanced by numerous scholarly studies. Hence, international research had to guide and support the researcher’s implementation of DGBL in the unchartered South African waters, so to speak, in particular by turning identified dilemmas in the literature into converse directives or guidelines in Table 2.2 for application during the empirical DGBL implementation. To this end, the literature contributed to partially explore aspects or logistics —conceptualised as directives and dilemmas in this chapter— involved in the availability; terms and conditions; and acquisition and affordability of educational digital games (see 1.4). The research diary (see 1.5.2 [c]) also contributed at a later stage to further exploration before and during the DGBL (see Figure 1.2). For the purpose of this study, *terms and conditions* include arrangements and requirements that form an integral part of DGBL.

The literature was also consulted to elaborate on two theoretical anchors of the study (see 1.2.5). The first one represents the four main sources of self-efficacy beliefs in Bandura’s (1994) self-efficacy theory, which are:

- mastery experiences
- vicarious experiences by social models
- social persuasion i.e. persuasion by others
- somatic and emotional states

The second theoretical anchor is represented by the learners’ beliefs regarding academic self-efficacy to:

- manage their own learning activities

- master different academic subjects
- fulfill personal, parental and teachers' academic expectations

Apart from deconstructing academic self-efficacy, related measures were also investigated by means of a literature study (see 1.4) to identify a suitable measure for the empirical research.

In lieu of playing DBE curriculum-supported games (that the researcher could not find as already stated above), she had to consult numerous collections of games upon operationalising the DBGL directives. The chapter is concluded by the matching of digital games to the curriculum of Grade 4 Natural Sciences and Technology according to the second phase of the data collection schedule in Table 1.2. The researcher illustrates how the DGBL directives were applied in answering the research sub-question pertaining to which educational digital games with reward systems support the curriculum of Grade 4 Natural Sciences and Technology (see 1.3).

2.2 DIRECTIVES AND DILEMMAS IN DGBL

DGBL is a developing area of study that is concerned with the use and application of digital games in the school environment. There is a growing body of literature suggesting that digital games can be effective tools for learning – Perrotta et al. (2013) already mentioned in chapter 1 coupled with Whitton and Maclure's (2015:1) various examples of digital games from early childhood education to primary and secondary schools. For example, Hwang, Sung, Hung, Huang and Tsai (2012) cited in Sung and Hwang (2018:120) developed a digital game to teach primary school learners about plants in a natural science lesson. Similarly, digital games about plants would be suitable for Grade 4 learners as they have a topic on plants in the curriculum (see Table 1.1). The content under this topic covers the basic structure of plants such as roots, stems, leaves, flowers, fruits and seeds. The suggested activity for learners in the CAPS states "identifying, labelling and describing the parts of a plant" (DBE 2011a:17). By including a game such as *Plant Parts Labeling* (TurtleDiary Plants Parts Labeling – Plant Game) as shown in Figure 2.1, which is based on a topic in Natural Sciences and Technology Grade 4, learners could consolidate information on the basic structure of plants.

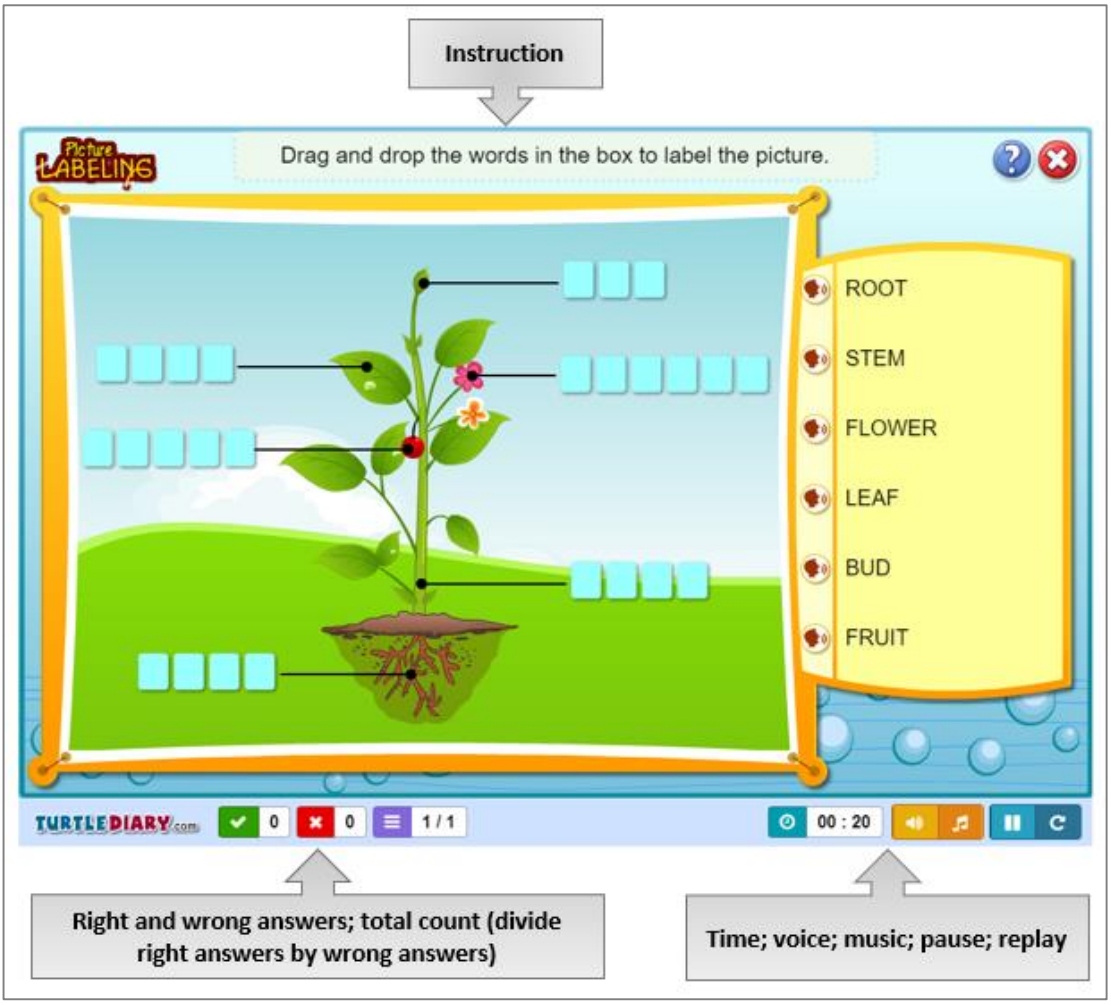


Figure 2.1: The *Plant Parts Labeling* game

Source: TurtleDiary Plants Parts Labeling – Plant Game

Prior to proceeding to the next section that indicates directives for when and how to implement DGBL, a few observations are added to the above plant game (also refer to Figures 2.1 and 2.2):

- The game is free; hence, affordability (see 1.4) is not an issue
- In an online environment, the game downloads onto a computer in a few seconds, i.e. it is easily accessible and available (see 1.4)
- The instruction is simple and clear; voice and/or music can be activated and adjusted; the game can be paused or replayed
- Rewards (see 1.1; 1.2.4; 1.4) are expressed in terms of
    - Number of correct responses
    - Higher total count after replaying and shorter times
    - Positive feedback

- The game appears to be suitable to introduce learners to DGBL, even those who are inexperienced at playing digital games as they should not be overwhelmed by all the information that they have to process (Wouters & Van Oosterdorp 2013:412).

Figure 2.2.: Positive feedback – 6 correct responses in 2 min 42 sec

Source: TurtleDiary Plants Parts Labeling – Plant Game

2.2.1 Directives for Implementing DGBL

As already stated, aspects or logistics are conceptualised as directives in this section, intended to guide when and how to implement DGBL. The researcher's point of departure is that DGBL is a joint effort between the teacher's ability to use appropriate digital games as a learning tool and the learner's willingness to engage in playing games and other educational activities such as discussions (Chee, Mehrotra & Ong 2015:517). Hung et al. (2015:185) add "a feeling of enjoyment" to the learners' active engagement. Several game scholars have attempted to embed science learning content into digital games (Kim, Ke & Paek 2017:626) as result of the associated gains (see 2.2.1 [a]) that are also qualified (see 2.2.1 [b] - [d]) below.

(a) Improved learning and motivation

Computer games could be an effective tool to facilitate learning (Kim et al. 2017), improving learners' higher order thinking and promoting leaners interactions with learning systems (Sung & Hwang 2018:120). A study by Dickey (2011) cited in Sung and Hwang (2018:120) shows that DGBL environments are able to promote learners' intrinsic motivation as well as curiosity.

Kim et al. (2017:626) state that many studies "find that digital games have strong potential to enhance students' learning by increasing confidence or motivation". According to Plass, Homer and Kinzer (2015:260) motivation is the most frequently cited aspect of games, especially when "incentive structures" or rewards (see 1.1; 1.2.4) such as stars or points are included.

The researcher links this directive, namely that DGBL facilitates learning, improves higher order thinking skills, increases confidence as well as promotes motivation and curiosity, to the disappointing TIMSS results (see 1.2.7) which showed that South Africa was one of the lower performing countries in Mathematics and Science. As already stated in chapter 1 (see 1.2.7), this small-scale research study could provide a point of departure to improve achievements in science in South Africa. Also, when Grade 4 learners are led to discover that learning through games can be fun (Campos & Moreira 2016:463-468), learning motivation is enhanced (see 1.1). Motivation forms the backbone of the study since Bandura (1994:73) deems motivation as one of the major psychological processes that activates self-efficacy (see 1.1; 1.2.5).

(b) Instructional support

Wouters and Van Oosterdorp (2013:412;413) state that instructional support to learners in DGBL environments comprises feedback, scaffolding, advice as well as guidance to select relevant information while ignoring irrelevant information. Interestingly, Wouters and Van Oorsterdorp (2013:421) find in their meta-analytic review of 29 studies that instructional support is only effective for primary school and college/university learners and not for high school learners. Thus, the researcher had to add instructional support to the Grade 4 learners' DGBL as they are primary school learners.

Kickmeier-Rust and Albert (2010) quoted in Sung and Hwang (2018:120) emphasise the importance of incorporating effective learning strategies into digital game-based activities. However, collaboration between learners as learning strategy does not improve learning (Wouters & Van Oosterdorp 2013:422), hence confirming the researcher's stance on solitary DGBL (in 1.1) derived from the research of Chen et al. (2015), although Bandura's vicarious experiences are deemed as a regular occurrence in the classroom during DGBL.

(c) Choosing appropriate games

Teachers should choose games with appropriate characteristics that allow for synergy between the learners' engagement and how knowledge and skills are imparted (Foster & Shah 2015:85). Also, teachers must be able to identify "teachable moments" during playing games to support the learners' engagement with the curriculum (Foster & Shah 2015:72).

(d) Additional factors

Turkay, Hoffman, Kinzer, Chantes and Vicari (2014:14) mention additional factors that should be taken into account in DGBL. These factors include, among others, the:

- time available for playing digital games in the classroom
- academic level of the learner
- learner's experience of playing digital games
- teacher's knowledge of digital games, in particular those that are suitable to attain learning outcomes

The directives for implementing DGBL as exposed by the literature is summarised in Table 2.1 below. Since the researcher was in search of aspects or logistics regarding educational digital games in support of her DGBL implementation for Grade 4 learners, she also operationalised these directives in Table 2.1.

Directive for DGBL in the literature	**Application of DGBL for Grade 4 Natural Sciences and Technology**
DGBL facilitates learning, improves higher order thinking skills, increases confidence as well as promotes motivation and curiosity.	Selected games that enabled learners to make connections, see relationships instead of learning isolated or abstract facts (see 1.1).
Provide instructional support during game play that comprises feedback, scaffolding, advice as well as guidance to select relevant information while ignoring irrelevant information.	Scaffolding of games (from easy to more intricate) and scaffolding of advice (from more to less); advised learners how to play and master the game; and gave feedback to learners.
Choose games with appropriate characteristics that allow for synergy between the learners' engagement and learning content. Teachers should identify opportunities for teaching.	Chose interesting games that supported the topics of Grade 4 Natural Sciences and Technology (see Table 1.1) while remaining watchful for appropriate moments to reinforce learning content either individually or in group context.
Available time for digital games in the classroom should be taken into account.	Limited time indicated that brief games had to be selected. Limited time also influenced the number of games that were being played – to attain a learning outcome, some learners repeated games while others were not played.
The academic level of the learner and the learner's experience of digital games should be weighed in DGBL.	Each Grade 4 learner's level of game expertise was monitored in order to provide appropriate support.
The teacher's knowledge of particular games to attain learning outcomes is important.	The researcher's knowledge of how to play each game ensured that the learning content was supported.

Table 2.1: Directives for DGBL implementation in this study

In search of more guidelines for DGBL implementation, the next section considers dilemmas uncovered by literature.

2.2.2 Dilemmas in Implementing DGBL

While several positive outcomes in using DGBL have been established in educational settings, there are also dilemmas that are associated with the implementation of DGBL in the classroom environment. However, the researcher attempted to turn the dilemmas or challenges into converse directives or guidelines as contained in Table 2.2 for application during the DGBL implementation in this study.

(a) Learner experts vs. teacher experts

Øygardslia (2018:86) expresses the view that in DGBL, learners might become experts including those that are not academically strong, which may pose a challenge for teachers. Although the traditional classroom set up recognises typical dynamics between teachers and learners, the technologically advanced generation of learners (see 1.1; 1.2.4) could expect the same level of expertise from their teachers during game play. Foster and Shah (2015:85) suggest that the gap can be closed by empowering teachers to find the intersection between the games, the attainment of learning goals and the school's infrastructure. The researcher couldn't help but to pause when she came across this "gold nugget" solution. It embodies the core of the study to a large extent: games and accomplished learning goals embedded in the school's infrastructure reflect the expertise of the teacher, not only expertise at playing games. Accomplishing learning goals refer to pedagogical competence that is highlighted in the next subsection.

(b) Unenlightened pedagogy vs. pedagogical competence

According to Foster and Shah (2015:72) there is a need to empower teachers with pedagogical competence in integrating computer games in the classroom environment. Pedagogical competence according to Novianti and Nurlaelawati (2019:170) is the competence to manage learners' education which comprises (i) understanding the learner; (ii) designing and implementing learning outcomes; and (iii) developing learners to achieve according to their potential. In the pedagogy of DGBL, "teachers need knowledge about the subject matter, methods of teaching and how to integrate different game approaches into teaching and learning" (Nousiainen, Kangas, Rikala & Vesisenaho 2018:87). It can thus be stated that pedagogical competence has to include technological advances such as digital games as part of its comprehensive competencies (Novianti & Nurlaelawati 2019:170).

When teachers familiarise themselves with the fast-changing technologies, they gain expertise (see 2.2.2 [a]) to engage with their learners through dialogue to help them make meaning of the curriculum as they play games. The roles of teachers in the pedagogy of DGBL coincide with instructional support (see 2.2.1 [b]) which Foster and Shah (2015:72) describe as observation of learners at play, feedback, scaffolding, guidance to learners to make connections with the learning outcomes and encouragement of learner reflection. Pedagogical competence should also take cognisance of leisure activities as opposed to learning activities in a digital environment as outlined in the next subsection.

(c) Leisure vs. learning

Øygardslia (2018:85) asserts that learners relax by playing digital games – Plass et al. (2015:258) cite whopping percentages of 99% of boys and 94% of girls playing digital games. Taking the learners' leisure activity into a formal learning environment might clash with their views of what learning in a classroom should be like. Øygardslia (2018:86) further argues that learners who are used to social media as a relaxation activity can find it difficult to understand how the task could be framed as a learning activity in the classroom. DGBL actually takes place in the intersection of formal and relaxation activities. The achievements of leisure digital activities are not necessarily repeated when brought into the classrooms because learners do not associate them with learning (Jenkin 2006 cited in Øygardslia 2018:86). Learners can thus fail to understand the purpose of the digital game.

(d) Additional obstacles

Foster and Shah (2015:71) mention additional obstacles that should be taken into account in DGBL which include:

- Timetables restricting the integration of long, complex games in class
- Poor physical infrastructure
- Dated technology
- Restrictive user account policies (requirements to maintain the account on computer networks)
- Lack of models to assist teachers in applying DGBL

Table 2.2 contains the researcher's attempt at developing guidelines from the DGBL challenges in the literature for application in her DGBL empirical research.

Dilemma in the literature	Directive for DGBL	Application regarding DGBL for Grade 4 Natural Sciences and Technology
Technologically advanced learners could expect the same level of expertise from their teachers during game play.	Games and accomplished learning goals embedded in the school's infrastructure reflect the expertise of the teacher, not only expertise at playing games.	Informed learners: *"I know that some of you are used to the best technology to play games and that you are better at playing games than I am, but I make the best of three things: (1) I use the technology at school to (2) play the game to (3) help you learn Natural Sciences and Technology. So, it is not just about the game – I want you to enjoy the game while learning at the same time!"*
Teachers lack pedagogical competence in integrating computers games in the classroom.	Foster pedagogical competence by developing learners to achieve according to their potential by integrating digital games that support the learning outcomes of Grade 4 Natural Sciences and Technology.	Matched educational digital games with reward systems to the curriculum of Grade 4 Natural Sciences and Technology (see 1.4).
Learners can view DGBL as relaxing.	Inform learners that the games are learning activities.	Informed learners in first session: *"These games are not the same as the ones that you play to while away the time; these games will help you to learn about your science lessons."*
Timetables restrict the integration of long, complex games in class.	Digital games should not be long and complex.	Selected brief games that were not too complex.
Poor physical infrastructure limits the application of DGBL.	The physical infrastructure should support DGBL.	Although the physical infrastructure was beyond the researcher's control, the school's physical infrastructure supported DGBL.
Old technology limits the integration of DGBL in the curriculum.	Technology should support the integration of DGBL.	Although the technology at school was beyond the researcher's control, the technology of the computer lab was up to standard for the integration of DGBL.
Terms and conditions of user account policies can restrict DGBL.	Regarding acquisition and affordability of educational digital games, acceptable user account policies can be negotiated or free games can be chosen.	Selected free games for DGBL.
A lack of models impedes the integration of DGBL.	Teachers should be guided by a model to integrate DGBL into the curriculum.	The literature study (see 2.2) that resulted in the guidelines outlined in Tables 2.1 & 2.2 were used.

Table 2.2: Dilemmas reversed into directives for DGBL implementation in this study

The focus of this study was on individual change in the development of academic self-efficacy in Grade 4 Natural Sciences and Technology learners who played educational digital games using Bandura's self-efficacy theory as theoretical framework (see 1.2.5) which is discussed below.

2.3 MAIN SOURCES OF SELF-EFFICACY BELIEFS

Self-efficacy, according to Bandura (1994:71) is formed from four distinguishing sources of information i.e. mastery experiences, vicarious learning, social persuasion and somatic and emotional states. Each of these sources will be discussed at length in the following sections.

2.3.1 Mastery Experiences

The most powerful of four distinguishing sources of information is mastery experiences, which refers to individuals own direct experiences (Woolfolk 2014: 368). People engage in tasks and activities, interpret the results and then use the results to develop beliefs about their abilities. For example, a javelin thrower undertakes he can go past the distance he last reached. Upon reaching his goal, his beliefs in his own personal efficacy are revised which will enable him to set a new goal (Usher & Urdan 2016:76). Successes raise efficacy beliefs, while failures lower efficacy. Bandura (1994:71) supports the above notion by stressing that successes build a strong belief in one's personal efficacy whereas failures weaken it. This implies that past successes raise the level of self-efficacy while repeated failures lower it. Bandura (1994:71) went on to discuss that some hindrances and difficulties that people encounter in life, serve a valuable purpose in educating that success usually involves continued effort. When people are convinced that they have what it takes to succeed, they endure in the face of hardship and quickly rebound from hindrances. Commenting on mastery experiences Usher and Urdan (2016:76) concur that they offer a powerful enhancement to self-efficacy and bears the strongest effect on self-efficacy.

2.3.2 Vicarious Experiences by Social Models

Besides interpreting their own experiences, individuals have a tendency of observing the actions of others and make inferences about themselves (Usher & Urdan 2016:76). Seeing other people who have similar abilities succeed on a task or reach a goal that is similar to the one a person might be facing is vicarious learning (Woolfolk 2014:368). Watching peers succeed raises the observer's self-efficacy and seeing them fail lowers it. Observing learners in the same grade succeeding by sustained effort will raise learners' belief that they too possess the capabilities to succeed (Schunk 1991:208). When the other individual modeling the behaviour is similar to the observer and is rewarded for his or her efforts, vicarious learning

would be more effective. Usher and Urdan (2016:76) also support this assertion by noting that greater exposure to modeled behaviour leads to stronger effects on self-efficacy. Usher and Urdan (2016:76) further stipulate that models can also expose onlookers to more effective ways of doing things thus raising self-efficacy. The impact of modeling on perceived self-efficacy is strongly influenced by perceived similarity to the models. On the other hand, watching others fail can discourage the learner observer from trying and diminish motivation and self-efficacy in the process (Schunk 1991:208). Furthermore, Usher and Urdan (2016:76) observes that social models save individuals time and expense of having to commence every activity before knowing whether they could succeed.

2.3.3 Social Persuasion i.e. Persuasion by Others

Encouragement and discouragement relating to an individual's ability to perform influences self-efficacy. Social persuasion is a way of strengthening people's views that they have what it takes to succeed (Bandura 1994:72). When people are verbally convinced that they have skills to master given activities, there are likely to put in more effort and sustain it rather than when they have self-doubts. Oral praises that communicate faith in a person's abilities can raise self-efficacy while critical appraisals can lead to self-doubt (Usher & Urdan 2016:77). In light of the above statement, Bandura (1994:72) suggests that situations that bring success should be created and avoid placing people in difficult situations where the chances of failure are high. Nevertheless, it is more difficult to inculcate high beliefs of individual efficacy by social persuasion alone than to weaken it. Unrealistic boosts of efficacy are rapidly disconfirmed by unsatisfactory results of one's efforts (Bandura 1994:72). Usher and Urdan (2016:77) advocate that if social support and guidance are presented in the early stages of learning that result in a sense of self -efficacy, it can result in sustained personal change. From the above statements on social persuasion, it is clear that genuine and realistic encouragement must be given by someone who is trustworthy such as teachers in a classroom situation.

2.3.4 Somatic and Emotional States

People also partially depend on their somatic and emotional states in judging their abilities (Bandura 1994:72). Emotional arousal is an essential source of information that can affect perceived self-efficacy in managing threatening situations (Bandura 1977:198). Learners form their own opinions about how these emotional states influence self-efficacy and academic achievements. They see these somatic reactions as signs that they can or cannot do a given activity. Usher and Urdan (2016:77) posit that a high degree of negative arousal can convince individuals of their inefficacy. People judge their exhaustion and pains and interpret these stress reactions to poor performance in activities that involves strength and stamina. Differences in levels of self-efficacy also influence physiological and affective states in

learners. Usher and Urdan (2016:77) assert that a person is likely to conclude that they do not have what it takes to speak in public by getting nervous and sweating at the same time when they think about it. High levels of self-efficacy decrease stress and anxiety during activities. Bandura (1993:133) was the first to note that when individuals have a high sense of coping self-efficacy, they are bold when taking on taxing and threatening activities. This may be due to the fact that they are at peace when they face difficult activities in contrast to those learners with a low self-efficacy who would be stressed when they face difficult tasks. These learners may develop strategies like avoidance tactics such as procrastination and passive-aggressiveness (Scott 2019). Moods are also seen to affect self-efficacy with positive moods enhancing self-efficacy while negative mood diminishing it. A similar observation was made by Usher and Urdan (2016:77) who postulate that low self-efficacy can lead to fictional realities that will further increase distress, while high self-efficacy allows individuals to control their emotions efficiently.

This discussion of the four main sources of self-efficacy beliefs leads us to an outline of learners' beliefs regarding academic self-efficacy.

2.4 LEARNERS' BELIEFS REGARDING ACADEMIC SELF-EFFICACY

The cogency of self-efficacy as a predictor of learners' motivation and learning have been clearly established for almost two decades (Verešová & Foglová 2018:180). Learners have a tendency to exert more determination regarding their studies when they have interest and enthusiasm for the subject. Learners are capable of managing their own learning and mastering different subjects when they have a high academic self-efficacy as discussed in the subsections below.

2.4.1 Managing Own Learning

Self-efficacy is a personal judgment of capability (Bandura 2006:307) and as such it influences the way people reason, motivate themselves and conduct themselves (Bandura 1993:131). Wang and Neihart (2015:65) went on further to stipulate that academic self-efficacy is linked with being the best in achieving goals or having an innate interest in doing things and being happy with the outcomes. Self-efficacy indicates a learner's ability to overcome problems and how long they can be able to face these problems. Learners with a low self-efficacy according to Bandura (1993:118) are uncertain about many things and often imagine failure. In support of the aforesaid, Gray and MacBlain (2012:95) also state that learners with a poor self-efficacy dwell on negative aspects, shy away from demanding responsibilities that require cognitive effort and constantly convince themselves that they cannot accomplish much in life.

In order to promote learners' beliefs in managing their own learning, they can be encouraged from an early age. At Grade 4 level, learners are expected to set goals for themselves, finish their work on time, do their homework and understand learned concepts. According to Harding, Nibali, English, Griffin, Graham, Alom and Zhang (2018:6) independent and energetic learners take control and are aware of their own learning – they successfully develop strategies to plan and understand their learning. Zhang (2014:48) stipulates that learning success, behaviour modifications, assessment performance and setting goals are connected to academic self-efficacy. Being able to strategize, control and assess personal learning as well as being able to adjust abilities are some of the characteristics of having a high self-efficacy (Byrne et al. 2014:410).

2.4.2 Mastering Different Academic Subjects

Learners with high academic self-efficacy according to Bandura (1993:133) have confidence in their capabilities to master academic subjects and these beliefs aid as predictors for future academic achievements. Bandura (1994:71) also stipulates that individuals with high assurance in their capabilities approach difficult tasks as challenges to be mastered rather than as threats to be avoided while individuals who doubt their capabilities shy away from difficult tasks which they view as a personal threat. Schunk (1991:214) support this notion by claiming that learners who believe they will encounter difficulty grasping material, are inclined to have a low sense of efficacy for learning, while the ones who feel they are capable of handling the information-processing difficulties should feel more efficacious. Conquering a challenging subject, for example, according to Bandura (1993:134), has an impact on academic enthusiasm and attainments.

Motivating learners is essential in developing their skills and make them reach their goals. Motivating learners towards learning according to Slavin (2006) cited in Titrek, Çetin, Kaymak and Kaşikçi (2018:77) makes them keen to study and would also help in shaping their behaviour envisioned for the subjects. Learners who are unmotivated are unwilling to learn and participate in classes which will affect their effort to learn (Titrek et al. 2018:77). At primary school level learners are facing various challenges which they are expected to solve. They ought to have a lot of determination in Natural Science and Technology, the focus of this study, as well as other subjects. Learners who are confident in their abilities and who have a high self-efficacy will not give up easily while those with a lower self-efficacy may not be able to withstand the pressure and give-up easily in their academic endeavours. Thus, high self-efficacy will positively affect performance and, in turn, good performance will enhance one's self-efficacy (Cheng et al. 2019:3).

2.4.3 Fulfilling Personal, Parental and Teachers' Academic Expectations

Learners have a role to play in as far as their learning is concerned. They have to meet and fulfill certain expectations that involve their own, parents' and teachers' with regard to their academic achievements. Each of these expectations are discussed in the following subsections.

(a) Personal academic expectations

Studies have revealed that learners with a high degree of academic self-efficacy set themselves challenging goals to which they are dedicated; they also have an interest in academic activities (Byrne et al. 2014:409). In support of the aforementioned, Meluso et al. (2012:498) found that the level of energy and the choice of actions that learners apply while playing games or executing other assignments in class, are determined by their level of academic self-efficacy. Learners who have a high self-efficacy are able to envisage themselves effectively completing tasks by providing their own positive guides and supports (i.e. they expect success), whereas those with a low self-efficacy envision failure and battle with fears of self-doubt (Bandura 1993:131). Self-efficacy controls the way individuals think and are motivated to such an extent that even less skilled people in a particular area can perform very well if they believe in themselves and inspire themselves to persevere.

This study investigated in particular the participants' personal academic expectations regarding persevering, succeeding in understanding science concepts as well as studying science.

(b) Parental academic expectations

Parents as socialising agents play a crucial role in the development of children's achievement motivation (Zong et. al. 2018:343). Commenting on the issue of parenting, Dehyadegary, Ebrahimi Nejad, Nasehzadeh and Divsalar (2014:94) hold the view that parenting is an unrewarding task that begins on the day the child is born – it is hard in the sense that all parents want to thrive in raising their child. In the light of the importance of parenting, Belfield and Levin (2007) cited in Dehyadegary et al. (2014:94) stipulate that academic self-efficacy has been connected to numerous influences distinctive to the home environment, such as parenting style. Parenting styles reveal a most important effect in the development of self-efficacy beliefs in children (Dehyadegary et al. 2014:94). Darling and Steinberg (1993) in Ren and Edwards (2015:617) define parenting styles as "a constellation of attitudes toward the child that are communicated to the child and create an emotional climate in which the parental behaviors are expressed". Parenting style is best seen as a contextual variable that moderates

the effects of specific parenting practice, and any development outcome related to parenting (Zong et al. 2018:344).

There are four types of parenting styles that Maccoby and Martin (1983) identify in Ren and Edwards (2015:617) as authoritative, authoritarian, permissive and neglecting parenting. Authoritative parents hold high expectations of maturity and demonstrate higher levels of warmth and responsiveness to their children while authoritarian parenting display low levels of warmth, use physical punishment and restrain the child's independence (Ren & Edwards 2015:617). Chen and Ho (2012) in Zong et al. (2018:344) examined the effect of diverse parent–child communication patterns on the relation between parental involvement and Taiwan students' academic belief and achievement. They found that when the parent–child relationship was mutual, children were more likely to adopt parents' values and achieve better performance. It can thus be stated that since parenting styles determine parental expectations, they could contribute to learners' academic achievements.

Most parents want their children to excel in school and have high expectations for them. Children whose parents convey the message that their children can accomplish certain goals, internalise these goals (Ren & Edwards 2015:615). In the light of the importance of parental expectations, Yamamoto and Holloway (2010:191) confirm that parental expectations generally play an important part in learners' academic accomplishment, in other words, the expectations that parents have with regard to their children's academic attainment, influence in turn the children's expectations and achievement at school. Yamamoto and Holloway (2010:191) are of the opinion that parental expectations are based on an assessment of the child's academic capabilities as well as the available resources for supporting a given level of achievement. Zong et al. (2018:345) carried out a study to enrich the literature by exploring parental influences on learners' attainment goals in China. China is a country where academic achievement is considered as one of the most vital factors for a child's future achievement thereby making the school environment highly competitive. Chinese parents have high academic expectations for their children which make them invest a huge amount of energy and resources in their children's education. Against this background, children may strive to outperform others in this competitive environment to repay their parents involvement (Chen [2015] in Zong et al. 2018:345). However, Zong et al. (2018:352) caution that when parents overemphasise their expectations in a psychologically controlling way, the internalisation process of these values can be hindered and led to children not endorsing the values and expectations conveyed by parents. When parents are too controlling, Zong et al. (2018:352) claim that academic self-efficacy development can be negatively affected.

(c) Teachers' academic expectations

Learners beliefs are affected by the learning context which entails other people who are around when learning takes place as well as the outer learning environment (Kaymakamoğlu & Atmaca 2016:38). Hornstra, Stroet, Van Eijden, Goudsblom and Roskamp (2018:325) express the view that the behaviour teachers show towards their learners may affect learners. For example, Tsiplakides and Keramida (2010:23) observed that teachers are often in the habit of giving praise to low achievers for achievement in relatively simple tasks, while withholding criticism for failure. In the same vein, Hornstra et al. (2018:325) add that when high expectation learners give wrong answers to a question, teachers are likely to rephrase the question so that the learner can get a better understanding while for low expectation learners, they are likely to give them the correct answer instead of rephrasing the question. Such strategies can have a negative effect on learner motivation and self-esteem; learners may consider this as an indication that the teachers have little confidence in their abilities and expects little from them. Teachers have a tendency of providing encouragement and feedback to high achievers and those who are low achievers are given more clarity and guidance (Hornstra et.al 2018:328). Hornstra et al. (2018:325) state that a mistaken teacher expectation may cause a learner to behave in accordance with the incorrect expectation. For instance, when a teacher regards a learner as intelligent and the learner is aware of it, the learner works harder to achieve thus impressing the teacher.

Learners' examination scores or preceding academic achievement can also be influential in teachers' expectancies and thereby boosting the learner's academic self-efficacy (Rubie-Davis, Hattie & Hamilton 2006:431). Higher teacher expectations based on good assessment marks lead to sustained academic achievement as the teacher would give positive feedback which increases learner confidence. The learner would exert more effort in their studies to maintain the standard thereby pleasing the teacher. The teacher expects the learners to continue producing higher marks according to the previous established results and this according to Rubie-Davis et al (2006:431) is known as sustaining expectation effects which prevent the possibility of change in results. This observation is supported by Zabel and Zabel (1996) cited in Tsiplakides and Keramida (2010:22) who state that expectations that teachers have for their learners in terms of behaviour and academic performance can have a strong impact on success. When teachers view intelligence as a fixed learner characteristic, chances are they are more likely to label learners as "unintelligent" or "clever" and teach them based on the label (Tsiplakides & Keramida 2010:23). When learners associate themselves with the negative label and see themselves as less able, it is likely to affect their perceived self-efficacy.

Learners' socio-economic background, gender and ethnicity can also influence teacher expectation (Tsiplakides & Keramida 2010:23). Similarly, Rubie-Davies et al. (2006:431) assert that minority status is usually connected to lower teacher expectations although it is not the focus of the study.

2.5 MEASURES

The above deconstruction of academic self-efficacy (see 2.3 and 2.4) is followed by an investigation into related measures to identify a suitable measure for the empirical research as already mentioned (see 1.4 and 2.1). Measuring academic self-efficacy can be done using different measures for learners at primary school level. These include the Patterns of Adaptive Learning Scale; the Children's Self-Efficacy Scale; the Morgan-Jinks Student Efficacy Scale; children self-efficacy scale and the student Report of Academic Self-Efficacy Scale. For the current research study, the Academic Self -Efficacy Subscale from Self-Efficacy questionnaire for children SEQ-C (Muris, 2001) was used.

2.5.1 Patterns of Adaptive Learning Scale (PALS) – Academic Efficacy Subscale

The PALS have been developed by a group of researchers using goal orientation theory to study the relationship between the learning environment and the learner's inspirations and behaviour (Midgley, Maehr, Hruda, Anderman, Anderman, Freeman, Gheen, Kaplan, Kumar, Middleton, Nelson, Roeser and Urdan 2000:2). The academic efficacy subscale is intended for use with learners in primary to high schools (Midgley et al. 2000). The PALS scales are grounded on research showing that a differential prominence on mastery and performance goals is associated with adaptive and maladaptive patterns of learning (Midgley et al. 2000:2). The various subscales of the PALS can be used together or individually. The academic efficacy subscale assesses learners' beliefs about their academic abilities in general. This subscale consists of 5 items and these items were designed for a Likert scale response using a 5-interval scale of "not at all true" to "mostly true". The measure is brief and has good evidence of reliability (Midgley et al. 2000:20). Higher scores reflect greater levels of perceived academic ability.

2.5.2 Children's Self-Efficacy Scale (CSES)

The CSES was designed to gain a better understanding of things that learners find challenging (Bandura 2006:326-327). Learners rate themselves by allocating a number from zero to 100 ranging from "cannot do at all" (zero) to "highly certain can do" (90 – 100). Two subscales, namely Self-Efficacy for Academic Achievement and Self-Regulated Learning appear to be particularly relevant for this study (Strive Together 2013:9). However, the Self-Efficacy for

Academic Achievement subscale is too wide as all school subjects such as reading, writing, language skills and social studies are included. Hence, the researcher does not consider the CSES a suitable measure for this study.

2.5.3 Morgan-Jinks Student Efficacy Scale (MJSES)

The MJSES was developed to gain information on elementary learner efficacy relating to school achievement (Jinks & Morgan 1999:225). Thirty items (Jinks & Morgan 1999:226) were designed for a Likert-scale response, using a four-interval scale of “really agree”, “kind of agree”, “kind of disagree”, and “really disagree” (Jinks & Morgan 1999:226). The MJSES also makes use of self-reported grades as a variable in the remaining four questions (Jinks & Morgan 1999:225). The original version of the scale was written to include four subscales that were talent, effort, task difficulty, and context (Jinks & Morgan 1999:225). The MJSES can be used for programme evaluation research as well as by teachers in the classroom when they want to understand more about their learners like, for example, how they perceive their talents (Jinks & Morgan 1999:228). However, the researcher found questions in the MJSES relating to reading, mathematics and social studies including the self-reported grades on these to be irrelevant to this study apart from the fact that learners may not remember what grades they obtained in the previous year. Furthermore, the researcher believes that shorter scales are more user friendly for young learners.

2.5.4 The Self-Description Questionnaire (SDQ)

The SDQ was developed based on Shavelson’s model of self-concept (Marsh, Relich & Smith 1983:174) in an effort to overcome some of the difficulties found in self-concept surveys. In order to investigate a variety of possible measures, the researcher’s interest in the SDQ was piqued by the relationship between Bandura’s mastery experiences at 2.3.1; the learner’s beliefs at 2.4.1 and 2.4.2; as well as the fulfillments of personal, parental and teachers’ academic expectations at 2.4.3. The SDQ measures three areas of academic domains, that is reading, mathematics and all school subjects, as well as non-academic domains including physical ability, physical appearance, relationship with peers and relationship with parents (Marsh et al. 1983:175). Response options range from “false,” “mostly false”, “sometimes false”, “sometimes true”,” mostly true” and “true”. There is a version of the SDQ specifically for primary school learners. Although the questions are fairly easy to answer, the researcher continued her search for a measure that is more focused on science in particular.

2.5.5 The Self-Efficacy Formative Questionnaire

The Self-Efficacy Formative Questionnaire is designed to measure learners' level of expertise in the two important components of self-efficacy which are believing that ability grow with effort and believing in one's ability to meet specific goals (Gaumer Erickson, Soukup, Noonan & McGurn 2018: n.p.). The questionnaire is suitable for learners from Grade 6 up to Grade 12 and has thirteen questions although these items are written on a Grade 8 reading level that might pose a challenge to the Grade 4 Natural Sciences and Technology learners in this study. However, accommodations like reading aloud, and explaining the items can be provided when necessary (Gaumer Erickson et al. 2018: n.p.). The learners complete the questionnaire by rating themselves on a 5-point Likert-type scale of 1 (not very like me) to 5 (very like me). The results are used by learners to build an awareness of how their perceptions and ability beliefs contribute to their academic success (Gaumer Erickson et al. 2018: n.p.). The questionnaire was found to be highly reliable using Cronbach's coefficient alpha. However, despite the promising application of this questionnaire, the researcher had two concerns – the Grade 8 reading level already mentioned and the lack of focus on science in particular.

2.5.6 Self-Efficacy Questionnaire for Children (SEQ-C) – Academic Self-Efficacy Subscale

The academic self-efficacy subscale of the SEQ-C (Muris 2001) was developed according to Bandura's self-efficacy theory that also represents the theoretical framework of this study (see 1.2.5). According to Minter and Pritzker (2015:2), Muris did no depart from the perceived self-efficacy scale (PSES) which was created earlier on by Bandura (1999). However, Bandura's scale was longer and had 37 questions (Minter & Pritzker 2015:2). The original SEQ-C by Muris (2001) was designed for young adolescents and contained 24 items that were subdivided into three 8-item subscales (Minter & Pritzker 2015:2). The SEQ-C measures academic self-efficacy, social self-efficacy and emotional self-efficacy and was designed in such a way that the subscales can be administered together or separately (Minter & Pritzker 2015:2).

For the current study, the original academic self-efficacy subscale items by Muris (2001) were modified to cater specifically for the Natural Science and Technology subject by inserting "Science" as shown in Figure 2.3. The adapted academic self-efficacy subscale from the SEQ-C (Muris 2001) has 8 questions which are rated on a Likert response using a 5-point scale with 1 being "not at all" and 5 being "very well". For the study, a total academic self-efficacy score was obtained by summing across all items ranging from 8 (low academic self-efficacy score) to 40 (high academic self-efficacy score).

The questionnaire was preferred for use in the study as motivated below:

- It is not time consuming and easy to administer. Minter and Pritzker (2015:2) supported this idea by noting that the scale has a simple format, domain specificity and it is brief.
- The data collection format is self-reporting and there are no costs associated with the use of the instrument.
- The adapted academic self-efficacy subscale from the SEQ-C (Muris 2001) is suitable for the age of Grade 4 learners.
- Furthermore, the questions of the adapted subscale were formulated in such a way that they would enable the researcher to answer the research sub-question posed in 1.3 on how academic self-efficacy is deconstructed as underpinned by Bandura's self-efficacy theory as theoretical framework; and how it is measured.
- Lastly, Minter and Pritzker (2015:2) stipulated that content validity of the subscales was scrutinized, and academic self-efficacy scores were positively associated with academic achievement.

	1 **Not at all**	2 **Seldom**	3 **Not so well**	4 **Well**	5 **Very well**
1. How well can you get the Science teacher to help you when you get stuck on schoolwork?	○	○	○	○	○
2. How well can you study Science when there are other interesting things to do?	○	○	○	○	○
3. How well can you study Science for a test?	○	○	○	○	○
4. How well do you succeed in finishing all your Science home-work every day?	○	○	○	○	○
5. How well can you pay attention during every Science class?	○	○	○	○	○
6. How well do you succeed in understanding Science in school?	○	○	○	○	○
7. How well do you succeed in satisfying your parents with your schoolwork?	○	○	○	○	○
8. How well do you succeed in passing a Science test?	○	○	○	○	○

Figure 2.3: Adapted Academic Self-Efficacy Scale, a subscale of the SEQ-C

Source: Muris (2001)

The chapter concludes by discussing the matching of digital games to the curriculum of Grade 4 Natural Sciences and Technology according to the second phase of the data collection schedule in Table 1.2.

2.6 MATCHING DIGITAL GAMES TO GRADE 4 CURRICULUM

After scouring through large collections of educational digital games, the researcher matched the games with the content and concepts of the Grade 4 Natural Sciences and Technology CAPS (DBE 2011a:20-26) for the second and third term when the DGBL took place (see Phase 2 in Table 1.2). The researcher applied the directives for DGBL in Tables 2.1 and 2.2 by:

- Selecting games that enabled the learner participants to make connections and see relationships instead of learning isolated or abstract facts.
- Choosing interesting games that supported the content and concepts of the topics of the curriculum.
- Adjusting to time limits in picking short games that were not too complex.
- Matching free games with reward systems to the content and concepts.

The first game in the selection of games, the *Plant Parts Labeling* game (TurtleDiary Plants Parts Labeling – Plant Game) in Figure 2.1, does not relate to content and concepts of the curriculum's second or third term. However, the researcher considered it suitable for the following reasons:

- The learning content and concepts of the topic, *Materials around us* (see Table 1.1), was still being taught when the DGBL sessions started. The game was thus played to revise learning content of the first term.
- The *Plant Parts Labeling* game (TurtleDiary Plants Parts Labeling – Plant Game) was a suitable introduction to DGBL, in particular for those who were inexperienced at playing digital games preventing them from being overwhelmed by all the information that they had to process (Wouters & Van Oosterdorp 2013:412). In the researcher's opinion success could be fairly easily obtained, hence encouraging the participants to engage in playing more games (see 2.2.1) in the following DGBL sessions.

Table 2.3 displays the games that were matched to the content and concepts of the Grade 4 Natural Sciences and Technology CAPS (DBE 2011a:20-26), including the *Plant Parts Labeling* game (TurtleDiary Plants Parts Labeling – Plant Game) for reasons explained above. The table also shows three educational songs that the researcher added as extras to enhance enjoyment (Hung et al. 2015:185) of the DGBL sessions. Further expositions of the games are included in the following chapters.

Term	Topic with content and concepts	Digital game
		Plant Parts Labeling game (TurtleDiary Plants Parts Labeling – Plant Game)
Term 2	**MATERIALS AROUND US** **Change of state** • heating and cooling (removing heat) cause solids, liquids and gases to change state:	*Changes in States of Matter* (TurtleDiary Changing States of Matter)

Term	Topic with content and concepts	Digital game
	- a solid first changes to a liquid (melting) when heated and then the liquid changes to a gas (evaporating) on further heating - gas first changes to a liquid (condensing) when cooled and then the liquid changes to a solid (freezing/solidifying) when cooled further	
Term 2	**MATERIALS AROUND US** **The water cycle** • water evaporates, condenses, freezes and melts in the water cycle	*Natural water cycle* (Legends of Learning)
Term 2	**SOLID MATERIALS** **Raw and manufactured materials** • examples of some raw materials we use to make other useful materials - sand is used to make glass - clay is used to make ceramics - coal and oil are used to make plastics, paints and fabrics - wood and fibre from plants are used to make paper - animal wool and hide are used to make fabrics and leather **Properties of materials** • raw and manufactured materials have specific properties. These properties can include being hard or soft, stiff or flexible, strong or weak, light or heavy, waterproof or absorbent	(i) Song: *Changing Materials Song by Peter Weatherall* (Weatherall[a]) (ii) Song: *Materials Song by Peter Weatherall* (Weatherall[b]) (iii) *Changes in Matter Word-O-Rama* (Learning Games for Kids)
Term 2	**STRENGTHENING MATERIALS** **Ways to strengthen materials** • there are different ways to strengthen materials (such as paper) to build a strong structure: - we can fold paper into hollow pillars which are circular, triangular or square - we can roll paper into long thin tubes (struts)	*Very easy paper house for kids* (YouTube[a])
Term 3	**ENERGY AND ENERGY TRANSFER** **Energy from the Sun** • energy is transferred from the Sun, to plants, to animals in a sequence known as an energy chain or food chain	*The food chain game* (Sheppard Software's Kid's Corner)
Term 3	**ENERGY AND SOUND** **Vibrations and sound**	

Term	Topic with content and concepts	Digital game
	• musical instruments make sounds through vibrations - the sound always moves outwards from the part that is vibrating - we can feel or hear vibrations - vibrations travel through materials such as air, water, plastic, metal and wood **Making sounds** • sounds can be made loud or soft (volume) • sounds can be made high or low (pitch) Suggested activity: Looking at pictures of the human ear, its parts and how sound travels through it	(i) Song: *Vibration Science Video* (YouTube[b]) (ii) *Ear Labeling – Science Game* (TurtleDiary Picture Labeling)

Table 2.3: Digital games matched to Grade 4 Natural Sciences and Technology

2.7 SUMMARY

In this chapter, the literature contributed to partially explore aspects or logistics — conceptualised as directives and dilemmas in this chapter— involved in the availability; terms and conditions; and acquisition and affordability of educational digital games (see 2.2). The literature was also consulted to elaborate on two theoretical anchors of the study (see 2.3 and 2.4). The first one at 2.3 represents the four main sources of self-efficacy beliefs in Bandura's (1994) self-efficacy theory, and the second theoretical anchor (see 2.4) is represented by the learners' beliefs regarding academic self-efficacy. Related measures were also investigated by means of a literature study (see 2.5) to identify a suitable measure for the empirical research. Finally, in lieu of playing DBE curriculum-supported games, the researcher consulted numerous collections of games upon operationalising the DBGL directives as depicted in 2.6.

The next chapter deals with the methodology in providing a sound scientific foundation for the empirical study as an objective in 1.4.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

In the previous chapters, the researcher reiterated that despite the global decline in Science performance, South Africa remains one of the lower performing countries in comparison to other countries at similar levels of development. South African schools are lagging behind with regard to e-learning despite policies and projects that are already in place (see 1.2.1). There is a need to promote positive attitudes towards science that stimulate Grade 4 learners' conceptual development which can be done by DGBL, as asserted by the researcher (see 1.2.7). Therefore, the following problem statement was formulated in 1.3:

> **How does DGBL with reward systems promote the development of academic self-efficacy in Grade 4 Natural Sciences and Technology learners?**

The following research sub-questions were stated to guide the study:

- How is academic self-efficacy deconstructed and measured?
- Which aspects or logistics are involved in the availability; terms and conditions; and acquisition and affordability of educational digital games?
- Which educational digital games with reward systems support the curriculum of Grade 4 Natural Sciences and Technology?
- How do reward systems in game-based learning contribute to the development of academic self-efficacy?

The aim of the study was to explore how DGBL with rewards system promote the development of academic self-efficacy in Grade 4 Natural Sciences and Technology learners. The researcher formulated the following objectives to enable her to achieve the aim of the study:

- Deconstruct academic self-efficacy and related measures by means of a literature study
- Conduct a literature study on the aspects or logistics involved in the availability; terms and conditions; and acquisition and affordability of educational digital games
- Match educational digital games with reward systems to the curriculum of Grade 4 Natural Sciences and Technology
- Acquire and download the educational digital games

- Determine how digital game-based learning with rewards systems support the curriculum of Grade 4 Natural Sciences and Technology?
- Examine how reward systems in digital game-based learning contribute to the development of academic self-efficacy in Grade 4 learners.
- Conduct an empirical investigation in a Grade 4 Natural Sciences and Technology classroom at a primary school in Gauteng by means of a case study strategy

This chapter focuses on the research design, methodology and sampling procedures selected to be used by the researcher to collect exploratory data throughout the expedition of the research undertaking as already shown in Figure 1.2. Data collection tools for data compilation are unpacked in terms of their significances. Analysis strategies suitable to this particular study are presented and discussed.

3.2 RATIONALE FOR EMPIRICAL RESEARCH

Desktop research showed that there is a growing body of literature in chapter 2, suggesting that the way people think and behave is determined by self-efficacy. Relevant journals, up-to-date books and information from the internet were studied in detail in answering the research sub-questions.

Regarding how academic self-efficacy is deconstructed and measured, self-efficacy was reviewed according to the theoretical framework of Bandura's Self-Efficacy Theory (see 1.2.5). The four main sources of self-efficacy, i.e. mastery experiences, vicarious experiences by social models, social persuasion and social and emotional states were discussed (see 2.3). Furthermore, academic self-efficacy was also reviewed in terms of learners' beliefs in their efficacy to manage their own learning activities, to master different academic subjects and to fulfill personal, parental and teachers' expectations (see 2.4). Six measures were perused to identify a suitable measure for academic self-efficacy (see 2.5). The researcher selected the Adapted Academic Self-Efficacy Scale, a subscale of the SEQ-C (Muris 2001) in 2.5.6 after identifying it as the most suitable for the current study after critically considering five other measures in 2.5.1 to 2.5.5.

With regard to aspects or logistics that are involved in the availability; terms and conditions; and acquisition and affordability of educational digital games, desktop research shed *some* light. The literature contributed to partially explore aspects or logistics —conceptualised as directives and dilemmas in Chapter 2— involved in the availability; terms and conditions; and acquisition and affordability of educational digital games. The directives intended to guide

when and how to implement DGBL (see Table 2.1). The researcher also identified dilemmas in the literature (see 2.2.2) and attempted to turn these dilemmas into guidelines (see table 2.2) for application during the DGBL implementation in this study.

In relation to matching educational digital games with reward systems to the curriculum of Grade 4 Natural Sciences and Technology, desktop research resulted in Table 2.3. Several collections of games were consulted in compiling Table 2.3 by:

- Selecting games that enabled the learner participants to make connections and see relationships instead of learning isolated or abstract facts.
- Choosing interesting games that supported the content and concepts of the topics of the curriculum.
- Adjusting to time limits in picking short games that were not too complex.
- Matching free games with reward systems to the content and concepts.

In conclusion of the discussion on desktop research, the researcher realised the following objectives as stated at 1.4 and 3.1:

- Deconstruct academic self-efficacy and related measures by means of a literature study
- Conduct a literature study on the aspects or logistics involved in the availability; terms and conditions; and acquisition and affordability of educational digital games
- Match educational digital games with reward systems to the curriculum of Grade 4 Natural Sciences and Technology
- Acquire the educational digital games

The researcher has already discussed in 1.2.7 that despite the global decline in science performance, South Africa remains one of the lower performing countries in comparison to other countries at similar levels of development. To promote positive attitudes towards science, the experiences which stimulate learners' conceptual development must be rewarding both intellectually and emotionally (Loxley et al. 2014:8). Therefore, the researcher asserted that this can be achieved by incorporating DGBL albeit in a small-scale empirical research study. Desktop research per se cannot achieve the researcher's envisioned contribution namely, to not only to create an engaging and fun-filled learning experience in a Gauteng Grade 4 Natural Sciences and Technology classroom, but also to contribute to the development of these learners' academic self-efficacy through the application of DGBL. This small-scale empirical research study could provide a portal for similar larger research projects to stimulate interest and improve achievements in science in South Africa.

Therefore, the empirical research contributed to investigate the problem statement by attaining the aim of the study in exploring how DGBL with reward systems promoted the development of academic self-efficacy in Grade 4 Natural Sciences and Technology learners by shedding additional light on the following objectives:

- Aspects or logistics involved in the availability of educational digital games by means of a research diary (see 1.5.2 [c]) before and during the DGBL (see Figure 1.2)
- Download of educational digital games
- Examine how reward systems in digital game-based learning contribute to the development of academic self-efficacy in Grade 4 learners.
- An empirical investigation in a Grade 4 Natural Sciences and Technology classroom at a primary school in Gauteng by means of a case study strategy

3.3 RESEARCH DESIGN

Yin (2003:19) claims that every single type of empirical research has an implicit, if not explicit, research design. A research design according to McMillan and Schumacher (2014:28) describes how the research will be conducted, including when, from whom and under what circumstances the data will be obtained. In laying the groundwork for the research design, a paradigm, approach, sources and information relevant to the problem statement as well as a time frame and a budget, among other things, were identified by the researcher. A descriptive and exploratory design was adopted for the current research. The choice of design assisted the researcher to execute the empirical research in a systematic way. In this type of design, the major purpose is the description of the state of affairs as it exists at the time of research, in this case, participants playing digital games in the computer lab at school. The design was also exploratory as it sought to uncover aspects or logistics that were involved in educational digital games.

3.3.1 Research Paradigm

A paradigm according to Kivunja and Kuyini (2017:26) outlines a researcher's philosophical orientation and has significant implications on every decision made in the research process. This implies that a paradigm informs readers how meaning will be created from the data gathered. Philosophical foundations that guide all researchers fall under basic principles about the ontology and epistemology which guide the choice of methodology.

Ontology according to Saunders et al. (2012) cited in Manus, Mulhall, Rage and Arisha (2017) looks at the nature of reality as seen through the eyes of the individual. Furthermore, it is the

philosophical study of the nature of existence or reality, of being or becoming, as well as the basic categories of things that exist and their relations (Kivunja & Kuyini 2017:27). For the current study, the researcher adopted the ontology of multiple realities as a series of uncoverings that imply that there is not one or absolute truth (Owen 1992:389). The knowledge acquired is socially constructed; reality is created through social interaction where social actors create partially shared realities and meanings (Saunders, Lewis & Thornhill 2019:137). Social constructionism that entails the collective generation of meaning, also suggests some kind of interaction between the inquirer and the knowable when these understandings are created (Lee 2012:405).

Epistemology as postulated by Wahyuni (2012) quoted in Manus et al. (2017) is the philosophy of how we come to attain knowledge and the opinions on how we generate, comprehend and use knowledge considered to be acceptable and trustworthy. Albeit it interpretive, the ontological assumption of the subjectivist epistemology of social constructionism is inevitably linked to the context of the 21st century technology revolution and required skills as well as e-learning in South African public schools (see 1.2.1). In this study, social constructionism in which understandings are cocreated through interpretation, uncovered the participants' meaning making of academic self-efficacy through DGBL with reward systems.

3.3.2 Research Approach

In order to attain the objectives of the empirical research (see 3.2, last par), a qualitative approach was selected to explore "meanings and insights in a given situation" (Mohajan 2018:23).

Excerpts from Mohajan (2018:23-24) that provide a comprehensive scientifically-based synopsis with citations, support the rationale for employing a qualitative approach as presented below:

- Qualitative research occurs in a natural setting, in this instance, the school's computer lab (1.5.1), enabling the researcher who is involved in the actual experiences to gather data (Creswell 2009). Figure 1.2 shows that the researcher supplemented the data collection by means of her research diary and participant observation.
- The research is multi-method in focus according to Denzin and Lincoln (2005) – see Figure 1.2. It uses interviews, diaries, journals, observations and immersions to obtain, analyse and interpret the data content analysis of visual and textual materials (Zohrabi 2013) as also applied to this study.

- The research works with non-numerical data (a participant DGBL journal and an individual face-to-face interview in 1.5.2 [b]) that seeks to interpret meaning from the data (Punch 2013); it focuses on words instead of numbers (Walia, 2015) while taking a snapshot of the participants' perception (Gentles et al. 2015), namely, the development of academic self-efficacy during DGBL in this research. Although the Adapted Academic Self-Efficacy Scale (Muris 2001) and the summative assessment of the Grade 4 Natural Sciences and Technology participants may appear as numerical data, they were used for triangulation.
- It investigates local knowledge, that is, Grade 4 Natural Sciences and Technology learners in Gauteng as exposed in 1.2.1, and provides an understanding of a given programme (Leedy & Ormrod 2001) such as selected digital games with reward systems in Table 2.3.
- According to Polkinghorne (2005), it is exploratory, and seeks to explain why a programme, such as DGBL, operates as it does in a particular context, namely in a school computer lab with adequate infrastructure (see Table 2.2).
- Denzin and Lincoln (2005) are of the opinion that the qualitative approach can have a profound impact on education.

3.3.3 Research Type

"The fundamental goal of case study research is to conduct an in-depth analysis of an issue, within its context with a view to understand the issue from the perspective of participants" (Harrison, Birks, Franklin & Mills 2017:8) is supported by Merriam (2009), Simons (2009), Stake (2006) and Yin (2014).

The researcher selected a case study design because it provided an opportunity to investigate the real-life experiences of the participants in the study. As stated above, a case study allows for an in-depth study to be carried out on a specific observable activity and/or phenomenon such as, in this case, DGBL and academic self-efficacy. This case study was bounded as described by Creswell (2012:465): "An in-depth exploration of a bounded system (e.g., activity, event, process or individuals) based on extensive data collection".

According to Yin (2003) cited in Gustafsson (2017), a single-case study is the best choice if the researcher only intends to study one single phenomenon in a single group, namely in this instance, how DGBL with reward systems promotes the development of academic self-efficacy —the phenomenon— in Grade 4 Natural Sciences and Technology learners as a single group.

The research type can thus be described as a bounded single-case design.

3.4 RESEARCH METHODS

Research methods refer to the processes and procedures implemented to execute research (Ponterotto 2005:132). Research methods clearly define procedures to generate and analyse data. The following section provides the techniques and procedures of site and participant selection including sampling, data collection, DGBL implementation, data analysis as well as trustworthiness and ethical considerations.

3.4.1 Site and Participant Selection

Selection of sites and participants is an important task a researcher must undertake during empirical research. In gaining a thorough understanding of the phenomenon, the qualitative researcher needs to purposefully select individuals and study sites.

The site selection has already been indicated in 1.2.1. Since the classrooms were not equipped with computers to integrate DGBL during Natural Sciences and Technology lessons, the study was carried out in a Gauteng public primary quintile 5 school that has a computer lab with tablets and computers with digital games for DGBL. The computer lab is equipped with 20 state of the art computers with Wi-Fi ensuring quick internet connectivity. Taking the threat of the COVID-19 pandemic into account, the sample size ensured adequate social distancing between the participants. The ICT teacher assisted at the site to upload the games prior to each session.

The sample size of ten male and/or female Grade 4 participants of one Natural Sciences and Technology class —representing the population— were sampled by using intensity sampling. The researcher selected participants who manifested sufficient intensity to illuminate the "nature of success" (Patton 1990:171) regarding the development of academic self-efficacy through DGBL, excluding extremely unusual cases. The researcher's role as teacher at the school allowed her "some prior information and considerable judgment" (Patton 1991:172) in purposefully selecting information-rich learner participants, although she remained mindful of her multiple roles as teacher and researcher. The selection criteria, following the exposition of time lines in Table 1.2, comprised the following:

- Towards the end of Term 1, after teaching the learners during the term on the topics contained in Table 1.2, the researcher already had some subjective prior information.
    - To inform her judgement, she administered the Adapted Academic Self-Efficacy Scale, a subscale of the Self-Efficacy Questionnaire for Children (SEQ-C)

(Muris 2001), to the entire class as part of informing her Natural Sciences and Technology teaching and learning – therefore, ethical clearance was not a prerequisite at that stage as it formed part of her general teaching practice. The researcher informed all the learners in the one Natural Sciences and Technology class that the scale would be repeated in Term 4 and that they would each receive individual feedback in the form of a brief report (see Appendix H). The scores ranging from 8 (low academic self-efficacy score) to 40 (high academic self-efficacy score) were transferred to a class list. The completed scales of all the learners were safely kept in a file.

- The class list containing the summative assessment ratings of all learners for Term 1 Natural Sciences and Technology was compared to the list with academic self-efficacy scores.
- Learners with both lower academic self-efficacy scores and summative assessment ratings were selected by adhering to ethical considerations. However, the researcher also applied her subjective judgement to include participants if she considered the potential of a specific learner as underdeveloped even if the learner did not meet the selection criteria, for example, the learner obtained both an average score and rating although the researcher believed that the learner had unrealised potential. Were identified participants not able to participate, due to, for example, unwillingness, absence of parental consent or logistical problems such as staying after school for the DGBL sessions, the researcher identified the 11th and/or 12th learner, and so on, with lower academic self-efficacy scores and summative assessment ratings until the sample size included 10 learner participants.

The only exclusion criterion was learners who were frequently absent from school during Term 1. As other learners in this class got wind by word of mouth of the DGBL sessions, the researcher had an ethical duty to include them in separate groups up to a maximum of ten to observe social distancing. However, they were not included in the empirical research.

3.4.2 Data Collection

The multimethod data collection took place in three phases as shown in Figure 1.2. These phases are:

- Prior to the implementation of the DGBL, referred to as *pre-DGBL*
- During the implementation of the DGBL, referred to as *during DGBL*
- After the implementation of the DGBL, referred to as *post-DGBL*

(a) Pre-DGBL

The **Adapted Academic Self-Efficacy Scale (Muris 2001)**, a subscale of the Self-Efficacy Questionnaire for Children (SEQ-C) is already discussed at 2.5.6 in the researcher's quest to find a suitable measure, including the rationale for selecting the measure as summarised below:

- The Adapted Academic Self-Efficacy Scale is easy to administer. The subscale has a simple format, domain specificity and is brief.
- The data collection format is self-reporting without any associated costs.
- The Adapted Academic Self-Efficacy Scale is suitable for the level of Grade 4 learners.
- The questions of the adapted subscale were formulated in such a way that they would enable the researcher to answer the research sub-question posed in 1.3 about how academic self-efficacy is deconstructed as underpinned by Bandura's self-efficacy theory as theoretical framework.
- Minter and Pritzker (2015:2) stipulate that subsequent to scrutinising the content validity of the subscales, academic self-efficacy scores were positively associated with academic achievement.

In addition to the discussion at 2.5.6, Muris (2001:146) reports the Cronbach's α between .85 and .88 for subscale scores, meaning that the internal consistency reliability of the SEQ-C is satisfactory.

The measure had two applications: (1) participant selection and (2) baseline assessment for selected participants.

The **summative assessment of Term 1 for Natural Sciences and Technology** is contained in a class list. On defining summative evaluation, Bloom et al. (2010) cited in Qu and Zhang (2013:336) pointed out that it evaluates learners' progress and compares learners' knowledge against specified standards at the end of an instructional unit. The data collection instrument had two applications: (1) participant selection and (2) baseline assessment for selected participants.

The **research diary** comprising of process notes and reflection was firstly used in the exploration and description of the aspects or logistics that were involved in educational digital games such as liaising with the ICT teacher by providing a schedule for uploads and checking that all the computers were ready (see 3.4.3 [c]). Secondly, the research diary was used to

record observations of the learners during Term 1. The data collection instrument had two applications: (1) acquiring prior information regarding participant selection and (2) acting as a filter for possible personal bias and prompting critical thought.

(b) During DGBL

The **Participant DGBL journal** consisted of predesigned sheets that the learner participants completed after each DGBL session. The sheets of each learner were placed in a file, named as the Participant DGBL journal. Journaling refers to a method of data collection where participants impart their encounters, conceptualisations, emotions and deliberations through writing and is employed in qualitative investigations to document participant experiences in their natural environments (Hayman, Wilkes & Jackson 2012:27).

The predesigned sheets were handed out at the beginning of each session as the second page had a score sheet that the participant learners filled during playing the games. An example of the Participant DGBL journal is included in Figures 3.1 and 3.2. All the sheets comprising the Participant DGBL journal are included at Appendix K. The first page of the sheets for the various games were always the same to facilitate the completion of the frequency table as discussed in 3.4.4 (d).

DGBL Journal

Your name: _____ **Todays date:** _____

Name of the game: _____

1. Mark the block OR blocks that describe you best with an X.

After playing the game, I feel:

	**Uncertain** 	**Like a winner** 	**Frustrated** 	**Bored** 

2. Mark your experiences and thoughts during this class with a tick (√) – there are no right or wrong answers

I was confident (believed in myself) that I could master the game.	When my friends mastered the game, I decided that I can also do it.
I knew that I could not master the game.	The game helped me to understand Science better.
I feel proud of myself.	I did not give up until I mastered the game.
I would like to play more Science games.	I am in a good mood today and did well.
I would not like to play more Science games.	I am in a bad mood today and did not do well.
It helped me a lot when my teacher said that I was doing well.	

3. Write other remarks here:

_____

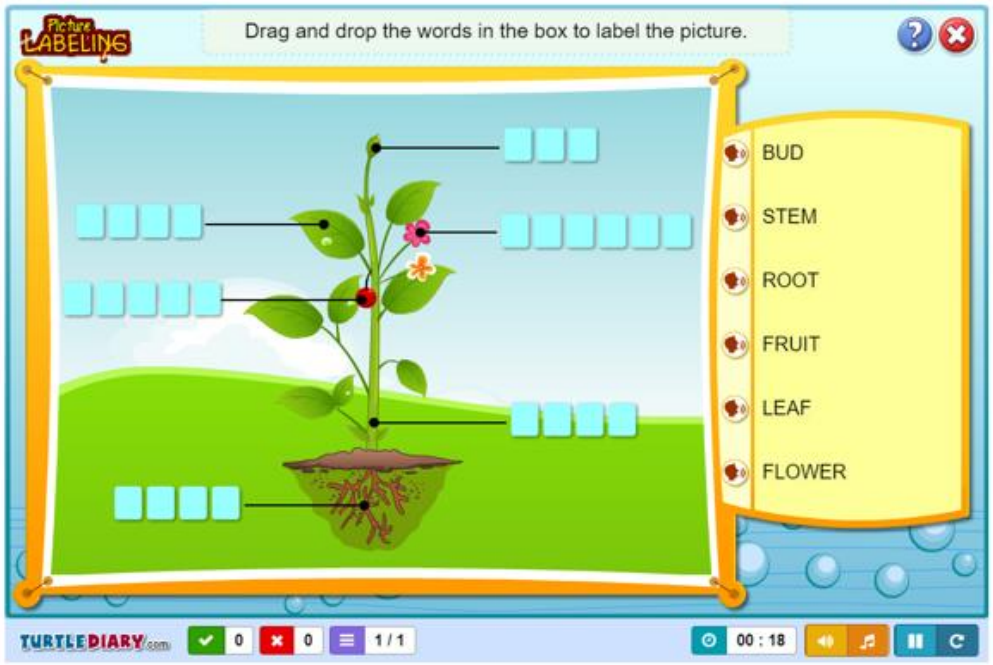
_____

_____

_____

Figure 3.1: Example of the Participant DGBL journal page 1

Score sheet – *Plant Parts Labeling*



Write down the number of the answers (√ and X)

Right answers	Wrong answers
1.	1.
2.	2.
3.	3.
4.	4.

Figure 3.2: Example of the Participant DGBL journal page 2

Participant observation during the DGBL was impromptu, that is, without an observation schedule. The impromptu observation of the participants during the DGBL was captured in the **research diary** directly after each session. The date of each session was indicated in the research diary (see Appendix M) containing the *Planning of digital games in Term 2 & 3 in 2021*).

The **research diary** in phase 2 (*during DGBL*) was also used to record challenges and successes during the DGBL sessions, for example, the viability of the researcher's preplanned

time schedule for DGBL sessions; personal thoughts; and ideas that arose during reflective thinking.

(c) Post-DGBL

At the beginning of Term 4, during phase 3, the **Adapted Academic Self-Efficacy Scale (Muris 2001)**, a subscale of the Self-Efficacy Questionnaire for Children (SEQ-C), was readministered to the learner participants for comparison to the initial baseline assessment. Although not relevant to the data collection per se, the scale was readministered to the entire class and contained in individual feedback reports as stated at 3.4.1. In keeping with the ethical duty to protect confidentiality (although the learners did talk among each other), the learner participants received their feedback in the same manner as the rest of the class; however, it was also addressed during the individual interviews that is also discussed in this post-DGBL section.

The participant learners' **summative assessment of Terms 2 and 3 for Natural Sciences and Technology**, contained in class lists, were used for comparison to the similar baseline assessment of Term 1.

An **individual face-to-face semi-structured interview** was conducted with each learner participant at the beginning of Term 4. Interviews in qualitative research can be structured, semi-structured or unstructured (Hancock & Algozzine 2006:40). In this study, semi-structured interviews according to an interview schedule (see Appendix L) were used to gather information from the learner participants. Predetermined questions emanating from the literature study as shown in Table 3.1, mostly open-ended questions, were asked. The responses of the participants afforded the researcher the opportunity to ask probing questions, where applicable or appropriate, in order to gain a more comprehensive understanding.

How the interview questions were informed by the literature	
Paraphrased question	**Literature reference**
1. Describe experience in one word	Section 1.2.4
2. How did games help, if any	Section 1.2.4; 2.2.1 (a)
3. Meaning making of mastery experience	Section 2.3.1
4. Observe the actions of others and make inferences about oneself	Section 2.3.2
5. Meaning making of encouragement or praise	Section 2.3.3
6. Emotional states in judging abilities	Section 2.3.4
7. Being happy with the Science outcomes	Section 2.4.1
8. Improve achievements in other subjects	Section 2.4.2
9. Self-belief to attain success in Science	Section 2.4.3 (a)

10. Parental involvement	Section 2.4.3 (b)
11. Teacher's role	Section 2.4.3 (c)

Table 3.1: Setting the interview schedule as informed by the literature

The interviews were conducted in the backroom office of the computer lab where there was no interruption, as a notice was placed on the door to indicate that an interview was in progress. The 10 interviews, lasting approximately 15 to 20 minutes each, were audio-recorded with the participants' and their parents' or legal caretakers' informed assent or consent for accuracy of transcription afterwards. The computer lab was sanitised before the DGBL sessions and social distancing maintained.

The data collection during the individual face-to-face semi-structured interview was supplemented by **participant observation** of each learner participant according to an observation schedule (see Appendix I). The schedule was completed directly after each interview without making any value judgements. De Vos, Strydom, Fouché and Delport (2011:329) argue that participant observation involves a systematic process of recording the behavioural patterns of the participants without necessarily questioning or communicating with them. In this study, the researcher was aware of the vulnerability of the learner participants subsequent to their lower academic self-efficacy scores and summative assessment ratings at the end of Term 1. Therefore, the researcher was particularly wary of their emotional states during the interview as result of probable ongoing negative self-talk and lack of mastery despite the opposite purpose of the DGBL. The researcher had an ethical duty to protect the wellbeing of the learner participants and referral to the school-based Support Team, if required, is discussed in Chapter 4.

3.4.3 Implementation of DGBL

The implementation of the DGBL sessions below includes the frequency and duration of the sessions; the time schedule for each session; liaising and collaboration with the ICT teacher; as well as instructions to the learner participants at the first DGBL session.

(a) Frequency and duration of the DGBL sessions

The DGBL sessions took place in Terms 2 and 3. The seven games (see Table 2.3) including three educational songs, added as extras to enhance enjoyment (Hung et al. 2015:185), were played at least twice over 10 sessions of 30 minutes each, every week (see Appendix M). Each learner participant received his or her personal headphones prior to each session. The headphones were cleaned for hygienic reasons after each session and placed in a plastic bag

with the name of the participant written on it. The researcher followed all the Covid-19 protocols like maintaining social distance, making sure that all participants were wearing masks and their hands sanitised before the commencement of DGBL sessions.

(b) Time schedule for DGBL sessions

The DGBL sessions could only be conducted after school as not to interfere with daily learning activities. Therefore, the researcher preplanned a time schedule for the DGBL sessions as shown in Table 3.2, also taking into account that the learner participants were tired after the school day.

Time allocation	Activity
5 min after end of school day	Participants gather in researcher's class room.
10 min	Researcher completes attendance register (see Appendix N). Making sure that all Covid 19 protocols are observed. Researcher hands each learner his/her headphones.
5 min	Walk to computer lab.
30 min	Researcher hands out score sheet(s) of the DGBL journal for the relevant game(s) to be played in the session (see Appendix K). Researcher provides instructions, support, feedback, etc. Participants play digital games and complete the score sheet(s) accordingly. Researcher makes mental notes regarding participant observation. Researcher collects the score sheets and headphones.
10 min	Participants adjourn, allowing time to engage with the researcher that would also be added to the participant observation.

Table 3.2: Time schedule for DGBL sessions

The researcher incurred cost, listed below, following the time schedule for DGBL sessions (in Table 3.2).

- Ten files for 10 participants for the Participant DGBL journals.
- Two sets of colour printed sheets of each game for each participant, amounting to 140 pages.

(c) Liaising with the ICT teacher

After the researcher approached the ICT teacher for assistance with the DGBL sessions, the teacher generously offered his assistance. The researcher reserved the computer lab several weeks in advance for the DGBL sessions. She provided the ICT teacher in advance with the

scheduled dates (see Appendix M) and websites of the particular games and songs in preparation of the DGBL sessions as depicted in Table 3.3.

Included in the initial preparation of the DGBL sessions, the researcher provided the ICT teacher with a printout of Table 3.3 so that he could make notes on it. The researcher had already prepared her notes for providing instructions. They both, that is, the researcher and the ICT teacher, accessed each game (without playing it) while the ICT teacher jotted down notes on the printout regarding the following instructions:

- Where each game or song had to be paused after “allowing” Adobe Flash to run if required.
- What had to be set to “full screen” and paused.

She also collaborated with the ICT teacher prior to each session about which games according to the corresponding numbers (in Table 3.3) were played during the session to ensure that they were already opened and paused when the learners entered the computer lab. The researcher also had a responsibility to double-check that all the computers were ready shortly before each DGBL session, the computer lab was sanitised and that social distancing were observed.

The content of Table 3.3 was also uploaded onto the desktop of each computer. The number of the games or songs and links are indicated by a slightly larger font to guide the participants, especially the more technologically advanced participants.

NUMBER OF THE GAME	SCIENCE TOPIC	NAME AND LINK OF THE GAME (click on the link to open the game or to listen to the song)
No 1	Revision	*Plant Parts Labelling* game https://www.turtlediary.com/game/plant-parts-labeling.html
No 2	**MATERIALS AROUND US** **Change of state**	*Changes in States of Matter* https://www.turtlediary.com/game/changes-in-states-of-matter.html
No 3	**MATERIALS AROUND US** **The water cycle**	*Natural water cycle* https://games.legendsoflearning.com/games/WyJnYW1lcyIsNzQ3XQ==
No 4	**SOLID MATERIALS** **Raw and manufactured materials** **Properties of materials**	(i) Song: *Changing Materials Song by Peter Weatherall* https://www.youtube.com/watch?v=e2QJt7gWcrI (ii) Song: *Materials Song by Peter Weatherall* https://www.youtube.com/watch?v=rAkQT1IgNdU (iii) *Changes in Matter Word-O-Rama* https://www.learninggamesforkids.com/changes-in-matter-games/changes-in-matter-word-o-rama.html
No 5	**STRENGTHENING MATERIALS** **Ways to strengthen materials**	*Very easy paper house for kids* https://www.youtube.com/watch?v=gkYKvTmMcdg
No 6	**ENERGY & ENERGY TRANSFER** **Energy from the Sun**	*The food chain game* https://www.sheppardsoftware.com/content/animals/kidscorner/games/foodchaingame.htm
No 7	**ENERGY AND SOUND** **Vibrations and sound** **Making sounds**	(i) Song: *Vibration Science Video* https://www.youtube.com/watch?v=VOnwW6TTTT4 (ii) *Ear Labeling – Science Game* https://www.turtlediary.com/game/ear-labeling.html

Table 3.3: Websites for DGBL in the computer lab – Natural Sciences and Technology

(d) Instructions to learner participants at the first DGBL session

The researcher mentioned in 2.1 the uncharted waters in which she found herself. Therefore, she also derived instructions for the DGBL from the literature as cross-referred in Table 3.4.

Instruction	Cross-reference
As you know by now, we are playing games in these sessions. I know that some of you are used to the best technology to play games and that you are better at playing games than I am, but I make the best of three things: (1) I use the technology at school to (2) play the game to (3) help you learn Natural Sciences and Technology. So, it is not just about the game – I want you to enjoy the game while learning at the same time!	See Table 2.2
These games are not the same as the ones that you play to while away the time; these games will help you to learn about your Science lessons. If we draw two circles that overlap [illustrate] and name the one circle "proper learning" and the other one "relaxation", learning in these game sessions actually takes place where the two circles overlap. We can call it a fun way of learning because it combines something of both circles.	See Table 2.2; 2.2.2 (c); 1.1
You will get rewards such as the number of right answers when you play the game, but you only compete against yourself and not against the others in class. You must be <u>your</u> best! You will complete a score sheet for each game that I will explain to you at the beginning of each session. Your score sheets will be placed in file with your name on it and for nobody else to see, except me.	See 1.1; 2.2.1 (a); 2.2.1 (b); Novianti & Nurlaelawati 2019:170 (see 2.2.2 [b]);
If you do not get it right the first time, it shows that you can play it again and try to improve. We all learn from our mistakes.	Snow 2016:6 (see 1.2.5); Whitton 2013:18 (see 1.2.4)
I am here to help you. Please ask if you need help. If this is the first time that you are playing games, you are not alone. I am also learning about playing games in Natural Sciences and Technology.	See 2.2.1 (b); 2.2.1 (d)
The best tip that I can give you is to belief that you are able to master the games. I strongly believe that you will achieve very well. Do not listen to any negative voices in your head telling you otherwise. Tell yourself: I can do this!	See 1.2.5
Unfortunately, time is limited in the game sessions, but we will continue with the games in the next session.	See 2.2.2 (d)

Table 3.4: Instructions for learner participants at the beginning of DGBL

3.4.4 Data Analysis

Data analysis precedes data reduction and display prior to arriving at findings. To prevent personal bias, assumptions or hunches, the researcher applied bracketing during data analysis as she was mindful of contamination as result of the following:

- Attrition of participants (that is, some of them left the group).
- The academic self-efficacy scores and/or summative assessment ratings at the end of Term 1 may not be a true reflection as they could have been influenced by adjusting to subject teaching (as opposed to class teaching up to Grade 3) and changing classes in Grade 4.
- The outcomes of the DGBL were influenced by extra learning support and special attention to the participants, that is, improvement in academic self-efficacy scores and/or summative assessment ratings during Terms 2 and 3 cannot solely be attributed to DGBL.

(a) Adapted Academic Self-Efficacy Scale (Muris 2001)

The marks for the scale are depicted in Table 3.5 by summing across all the selected items, followed by the academic self-efficacy category in Table 3.6 according to Sabatelli, Anderson and LaMotte (2005:53-56).

	1 **Not at all**	2 **Seldom**	3 **Not so well**	4 **Well**	5 **Very well**
1. How well can you get the Science teacher to help you when you get stuck on schoolwork?	1	2	3	4	5
2. How well can you study Science when there are other interesting things to do?	1	2	3	4	5
3. How well can you study Science for a test?	1	2	3	4	5
4. How well do you succeed in finishing all your Science home-work every day?	1	2	3	4	5
5. How well can you pay attention during every Science class?	1	2	3	4	5
6. How well do you succeed in understanding Science in school?	1	2	3	4	5
7. How well do you succeed in satisfying your parents with your schoolwork?	1	2	3	4	5
8. How well do you succeed in passing a Science test?	1	2	3	4	5

Table 3.5: Scoring of the Adapted Academic Self-Efficacy Scale (Muris 2001)

Score	Category
8	Low
16	Below average / lower average
24	Average
32	Above average / higher average
40	High

Table 3.6 1: Categories of the Adapted Academic Self-Efficacy Scale (Muris 2001)

Although the categories are an indication of academic self-efficacy, the researcher used the "raw scores" (that is, the actual scores) in both administrations of the Adapted Academic Self-Efficacy Scale (Muris 2001) in comparing the pre-DGBL to the post-DGBL scores of each learner participant as tabled in Chapter 4.

(b) Summative assessment of Grade 4 Natural Sciences and Technology

The summative assessment rating of each learner participant in Term 1 was compared to the average of the particular learner participant's summative assessment ratings in Terms 2 and 3 in determining differences, if any. A table containing the two sets of summative assessment ratings per learner participant is included in Chapter 4. A legend that clarifies the ratings is also included in the table.

(c) Research diary

Data analysis of the research diary comprised two processes. Firstly, it was incorporated into the exploration and description of the aspects or logistics that were involved in educational digital games (see 1.3). Secondly, a thematic analysis as described in 3.4.4 (e) was done to organise, code and categorise the impromptu participant observation during the DGBL sessions.

(d) Participant DGBL journal

Only page 1 of one set of the sheets, containing the participant's best performance as completed after of the DGBL session, was transferred to a frequency table by indicating it with a cross, as shown in the example below (see Table 3.7) while the "other remarks" on page 1 were coded and categorised as exposed in the next subsection at 3.4.4 (e). The second page

(that is, page 2) were only used by the learner participants to keep tabs of their scores and thus not analysed. The actual frequency table is included in Chapter 4.

Table 3.7: Example of frequency table for the Participant DGBL journal

	Participant	Felt very good	Felt uncertain	Felt like a winner	Felt frustrated	Felt bored	Felt confident	Knew game cannot be mastered	Felt proud	Eager to play more games	Not eager to play more games	Teacher praised me	Friends mastered the game, so can I	Game helped to understand Science better	I persevered	Good mood – did well	Bad mood – did not do well
Plant Parts Labeling	P1																
	P2																
	P3																
	P4																
	P5																
	P6																
	P7 etc.																
Changes in States of Matter	P1																
	P2																
	P3																
	P4																
	P5																
	P6																
	P7																
	P8																
	P9																
	P10																
Natural water cycle	P1																
	P2																
	P3																
	P4																
	P5																
	P6																
	P7																
	P8 etc.																

The information of the frequency table was transferred to Table 3.8 to show the influence of DGBL on academic self-efficacy according to Bandura's (1994) four main sources of self-efficacy beliefs, which are:

- mastery experiences (1.2.5; 2.3.1)
- vicarious experiences by social models (1.2.5; 2.3.2)
- social persuasion i.e. persuasion by others (1.2.5; 2.3.3)
- somatic and emotional states (1.2.5; 2.3.4)

The actual table is included in Chapter 4.

Number of participants out of a total of 10 participants playing 7 games, with a maximum response of 70*		**Option selected on page 1 of DGBL journal**	**Bandura's four main sources of self-efficacy beliefs**
Response number	Percentage		
e.g. 50/65	e.g. 77%	Felt very good	Mastery experiences
		Felt like a winner	Mastery experiences
		Felt confident	Mastery experiences
		Felt proud	Mastery experiences
		Eager to play more games	Mastery experiences / Social persuasion i.e. persuasion by others
		Teacher praised me	Social persuasion i.e. persuasion by others
		Friends mastered the game, so can I	Vicarious experiences by social models
		Game helped to understand Science better	Mastery experiences
		I persevered	Mastery experiences
		Good mood – did well	Somatic and emotional states
* **The attendance register assisted in determining the possible maximum response, e.g. 50/65, which was also expressed as a percentage, e.g. 50/65 = 77% of the participants**			

Table 3.8: Example of the influence of DGBL on academic self-efficacy

(e) "Other remarks" in Participant DGBL journal, individual face-to-face semi-structured interview and impromptu participant observation

A thematic analysis to organise, code and categorise data was done using the participants' encounters, conceptualisations, emotions and deliberations regarding the (1) "Other remarks" in the Participant DGBL journal; (2) the interviews as shown in Figure 1.2; as well as the (3) impromptu participant observation during the DGBL sessions as recorded in the research dairy.

Braun and Clarke (2006) cited in Nowell, Norris, White and Moules (2017:2) describe thematic analysis as a technique for identifying, scrutinising, organising, describing and reporting themes found within a data set. King (2004) quoted in Nowell et al. (2017:2) expresses the view that thematic analysis is useful in examining the different viewpoints of research participants, highlighting similarities and differences and generating unanticipated insights. The rigorous thematic approach can yield an insightful analysis that answers particular research questions (Braun & Clarke 2006:97).

The researcher applied first and second cycle coding procedures. First cycle coding according to Saldaña (2009:45) refers to the direct and undisputable methods that are used during the initial coding of data. Second cycle coding encompasses the analytical proficiencies such as categorising, ranking, extracting, hypothesising and theory construction (Saldaña 2009:45). Descriptive and process coding were applied during the first cycle coding while focussed coding was utilised in the second cycle.

The researcher applied descriptive codes which require little interpretation by using words and phrases drawn directly from participants' views as well as from making reference to concepts drawn from Bandura's self-efficacy theory. Saldaña (2009:70) advocates that descriptive coding is a suitable option when analysing journals, diaries and process notes. Process coding was applied which, according to Saldaña (2009:77), singularly signifies action, such as, regular observable activity as well as more abstract actions such as that of body language, within the qualitative data – see *Participant observation* at 3.4.4 (f), supplemented by impromptu observation in the research diary. This method of coding seemed appropriate for this study as it, according to Saldaña (2009:77), aims to observe interaction and emotion in response to a specific situation such as the DGBL sessions.

During second cycle coding, the researcher applied focused coding. Focused coding seeks to identify codes which are most frequent and significant to develop key categories or themes from the initially coded data (Saldaña 2009: 155).
The researcher employed the following steps in analysing data:

- The first step was to familiarise herself with the data by means of reading and re-reading the data from the “Other remarks” in the Participant DGBL journals, individual face-to-face interviews and impromptu observation while probing for similarities and differences in themes. Braun and Clarke (2006:87) support the above by noting that familiarising is focused on reading and re-reading the data, noting down initial ideas. This enabled the researcher to get an understanding of DGBL and academic self-efficacy from each participant’s point of view. The researcher also kept the research sub-questions and objectives of the study close for quick reference.
- Coding then followed which entails a process of investigating and problem solving that classifies and connects data to formulate an idea, followed by relating all the data regarding that particular idea to form a category, which subsequently encompasses collective or mutual codes pertaining to the problem statement (Saldaña 2009:8). The researcher used information identified as relevant to generate initial codes.
- The next stage was marked by searching for themes, collating codes into potential themes, gathering all data relevant to each potential theme (Braun & Clarke 2006:87). The researcher then studied the listed codes to formulate categories or patterns from the main and important codes. A category of the research is common codes linked to the research questions. By looking at the categories, the researcher identified common patterns, that is, differences, similarities, frequency and correspondence. Patterns in the linked data were identified for sub-themes and theme development. The researcher reviewed them, checking to see if the themes worked in relation to coded extracts and the entire data set.
- Reviewing themes, checking if the themes work in relation to the coded extracts and generating a thematic ‘map’ of the analysis (Braun & Clarke 2006:87), the researcher had to make sure that the themes were useful and accurate representations of the data. Different themes derived regarding the problem statement in 1.3 were then linked to the theoretical framework in 1.2.5. In short, it entailed “[d]defining and naming themes: Ongoing analysis to refine the specifics of each theme, and the overall story the analysis tells, generating clear definition and names for each theme” (Braun & Clarke 2006:87).

- Finally, the researcher focused on writing a narrative about the data by presenting the findings accompanied by supportive verbatim transcriptions.

(f) Participant observation according to the observation schedule

Participant observation was added between square brackets (that is, […]) to the verbatim transcriptions of the individual face-to-face semi-structured interviews in preparation for coding to either supplement or contradict verbal responses.

Table 3.9 provides an overview of the data collection instruments during the three phases and data analysis. It also serves as an introduction to the discussion on trustworthiness in the next section.

Data collection instrument	pre-DGBL	during DGBL	post-DGBL	Analysis
Adapted Academic Self-Efficacy Scale	X		X	Scored and compared
Summative assessment of Term 1 for Natural Sciences and Technology	X			Informed participant selection Compared to post-DGBL
Summative assessment of Terms 2 and 3 for Natural Sciences and Technology			X	Compared to pre-DGBL
Research diary	X			Incorporated into exploration and description of aspects or logistics involved in DGBL Informed participant selection
		X		Thematic content analysis of impromptu participant observation Challenges and ideas were gathered and condensed
Participant DGBL journal, page 1 excluding "other remarks"		X		Frequency table followed by synopsis displaying the influence of DGBL on academic self-efficacy according to Bandura's (1994) four main sources of self-efficacy beliefs
Participant DGBL journal, page 1, "other remarks"		X		Thematic content analysis
Individual face-to-face semi-structured interview			X	Thematic content analysis
Participant observation according to observation schedule			X	Added to verbatim transcriptions of the individual face-to-face semi-structured interviews to either supplement or contradict verbal responses

Table 3.9: Overview of data collection instruments, phases of collection and analysis

3.4.5 Trustworthiness

Trustworthiness has become a term used within qualitative research in order to describe the strength of the claims that are made (Hammond & Wellington, 2013:146). Trustworthiness, according to McMillan and Schumacher (2014:330), refers to the extent to which the data obtained in the study is plausible, credible and trustworthy.

For this study, the credibility of the research is enhanced by triangulation. According to Denscombe (2007:134), triangulation involves the use of different methods (method triangulation), different sources of data (triangulation of sources), or different researchers within the same study (analyst triangulation). This study applied method triangulation by using multi-method data collection as shown in Table 3.9. It also applied triangulation of sources by interviewing various participants. Lastly, analyst triangulation was applied with the assistance of the researcher's supervisor.

The subjective analysis of data was curbed to a certain extent by bracketing although the researcher could bring bias to the study being a teacher at the particular school where the research was conducted. Gearing (2004) cited in Tufford and Newman (2010:83) clarifies bracketing as a "scientific process in which a researcher suspends or holds in abeyance his or her presuppositions, biases, assumptions, theories, or previous experiences to see and describe the phenomenon". The researcher made notes and kept a research diary throughout the research process to promote the researcher's reflections on being an educator as well as being the researcher (Creswell 2014:202). Credible research necessitated that the researcher remained neutral at all times. Data collection was thus entered with no predetermined outcome assumptions.

Commenting on bias, Birt, Scott, Cavers, Campbell and Walter (2016:1802) acknowledge that researcher bias may be reduced by actively including the research participants in checking and conforming the results. Member checking was used to determine the accuracy of the analysis by taking the categories back to the participants (Creswell 2014:251) albeit on a modified level that the participants could understand.

3.4.6 Ethical Considerations

Research ethics are focused on what is morally proper and improper when engaging with participants (McMillan & Schumacher 2014:129). Most educational research deals with human

beings, therefore, the researcher is ethically responsible for protecting the rights and welfare of the subjects who participate in the study (McMillan & Schumacher 2014:23).

(a) Permission

The researcher applied for the following permissions that were granted:

- the Research Ethics Committee of the University of South Africa (see Appendix A)
- the Department of Education Johannesburg East District 9 (see Appendix B)
- the school principal and governing body (see Appendix E)

(b) Informed consent and assent

Informed consent or assent is an ethical consideration that required the researcher to first obtain consent from the learner participants' parents or legal caregivers and the learner participants prior to the empirical research. Therefore, the researcher obtained:

- parental or legal caregiver's consent (see Appendix F)
- learner participant's assent (see Appendix G)

(c) Confidentiality and anonymity

Researchers have a responsibility to protect the individuals' confidentiality and that of other persons in the setting (Macmillan & Schumacher 2014:334). Confidentiality is the ability of the researcher to keep information obtained from the participants from reaching the hands of unauthorised persons. All the information about the participants and DGBL was treated with the strictest confidentiality. McMillan and Schumacher (2014:134) stated that confidentiality should be maintained by ensuring that the data cannot be linked to individual participants by name. Pseudonyms in this case were used ranging from P1 to P10. However, anonymity could not be included as the researcher was already familiar with the participants.

(d) Storage and data security

The researcher kept the hard copies of the data safely in a locked cabinet. These copies would be stored for a period of five years. Some of the data was stored on a password protected external drive, also stored in a locked cabinet. The computers in the computer lab with the saved games were password protected. After the storage time lapsed, the hard copies will be shredded and recorded electronic copies will be permanently deleted from the hard drive of the computers and external hard drive through the use of a relevant software program.

3.5 SUMMARY

In this chapter, the researcher provided a description of the research methodology that was used during the research. The researcher reported on a number of research concepts including the rationale for empirical study, the research design, research approach, research type, research methods, that is, the site and participant selection including sampling, data collection, DGBL implementation, data analysis as well as trustworthiness and ethical considerations. The following chapter presents the results and discusses the findings of the empirical investigation in detail.

CHAPTER 4

ANALYSIS, PRESENTATION AND DESCRIPTION OF THE RESEARCH FINDINGS

4.1. INTRODUCTION

This chapter reports on the results constructed from the exploration of the development of academic self-efficacy in Grade 4 learners through the use of digital game-based learning (DGBL). The chapter gives an insight into the participants' experiences of game-based learning, participant observation, participant journals, researcher's diary and the 10 participants' Term 2 and 3 summative assessments of Natural Sciences and Technology. The researcher used aims and objectives (see 1.4) to steer her analysis through the huge amount of data that was captured. Literature review shed light on some of the objectives of the study (see 3.2). Furthermore, the study sought to explore how DGBL with reward systems promoted the development of academic self-efficacy in Grade 4 Natural Sciences and Technology learners by shedding light on the following objectives:

- Examine how reward systems in digital game-based learning contribute to the development of academic self-efficacy in Grade 4 learners.
- Conduct an empirical investigation in a Grade 4 Natural Sciences and Technology classroom at a primary school in Gauteng by means of a case study design.

This chapter therefore focuses on the discussion of findings and analysis of data. Some data was collected using interviews while incorporating observations of participants during DGBL. Data collection was explained in detail in chapter 3. The researcher recorded participants' experiences, her thoughts and feelings in her diary before, during and after DGBL (see 3.4.4 [c]). The findings of the research are discussed according to the themes, with the aim to answer the research questions. The researcher applied bracketing to curb subjective analysis of data (see 1.5.2.d). Bracketing according to Creswell (2003) cited in Weatherford & Maitra (2019:91) is a technique whereby the researcher separates own experiences from what is being studied. Member checking as proposed by Creswell (2014:251) was also used to determine the accuracy of the findings by taking the categories back to the participants.

4.2 PARTICIPANTS

The sampling and selection of the participants was discussed in Chapter 3 (see 3.4.1) and comprised of 10 Grade 4 learners. Grade 4 learners completed the Adapted Academic Self-Efficacy Scale, a subscale of the SEQ-C (Muris 2001) (see Appendix H) before and after the implementation of the DGBL. The age of the participants for this study varied from 9 years to 11 years of age with an average age of 9.9 (see Table 4.1). Confidentiality was constantly assured, learners' names on the questionnaire were not used when data was entered into the computer, but each learner was represented by a number. All participants enclosed their age and gender when completing the questionnaire. The participants' personal characteristics assisted in eliminating any potential sample biases that would emanate from participants' profiling.

4.2.1 Participants' Gender

The results depicted in Figure 4.1, reflect a sample with participant-gender balance. The sample had five (50%) girls and five (50%) boys. This implied that the findings were neither dominated by girls nor boys which validated generalisation of results by gender.

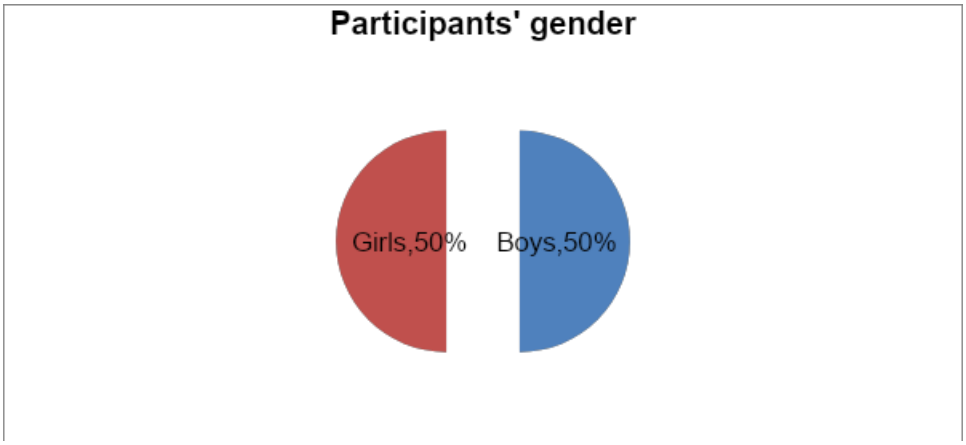


Figure 4.1: Participants' gender

4.2.2 Participants' age

In Table 4.1, the age distribution in the study sample is illustrated. The frequency distribution of the participants age are as follows: 9 years (2 participants): 10 years (7 participants) and 11 years (1 participant). The sample age distribution show that participants average age was 9.9 years.

Age (in years)	9	10	11
Participants' frequency	2	7	1
Average age	99/10 = 9.9		

Table 4.1: Participants' age

4.3 DISCUSSION OF FINDINGS

4.3.1 Adapted Academic Self-Efficacy scale (Pre-DGBL and Post DGBL performance)

The Adapted Academic Self-Efficacy Scale (Muris 2001), a subscale of the Self-Efficacy Questionnaire for Children (SEQ-C) was administered to participants before intervention (pre-DGBL) and after the DGBL intervention (post DGBL). Raw scores were used in comparing the pre-DGBL to the post-DGBL scores of each learner participant. The percentage increase in individual participants' results reflect significant academic self-efficacy improvement. Participant 1 had the highest percentage increase (240%) (see Table 4.2). The researcher calculated the percentage increase by subtracting the post-DGBL score from the pre-DGBL score. The answer would be the increase which was then divided by the pre-DGBL score and then multiplied by 100. Participant 1 had the highest percentage increase which was calculated as follows: Initial score= 10, final score =34

Percentage Increase = [(34-10)/10] x 100 = (24/10) x 100 = 240% Therefore, the percentage increase in the academic self-efficacy of participant 1 is 240%.

The results demonstrate the variations in the participants' level of academic self-efficacy with regards to their pre-DGBL and post-DGBL scores. There was a significant improvement in participants' academic self-efficacy as a result of the application of digital game-based learning.

	PARTICIPANTS									
	1	2	3	4	5	6	7	8	9	10
Pre-DGBL	10	15	9	11	15	18	18	16	15	10
Post-DGBL	34	32	29	32	27	33	31	34	29	30
Increase	24	17	20	21	12	15	13	18	14	20
% increase	240	133.3	222.2	190.9	80	83.8	72.6	112.5	93.3	200

Table 4.2: Comparison of pre-DGBL and post-DGBL results

The presentation of results in Figure 4.2 comparative bar graph below clearly depicts the disparities between the pre-DGBL and post-DGBL results. Participants had a low academic self-efficacy before DGBL which increased after the DGBL intervention (post DGBL). This implies that there was an increase in academic self-efficacy which was being measured by the Adapted Academic Self-Efficacy Scale (Muris 2001), a subscale of the Self-Efficacy Questionnaire for Children (SEQ-C). The performance of all participating learners showed significant improvement from the pre-DGBL results after digital games intervention. Participants with low pre-DGBL results benefited the most from the DGBL as evidenced by the higher incremental percentages depicted in Table 4.2. Therefore, there was substantial evidence to support the learners' Natural Science and Technology performance improved after DGBL intervention.

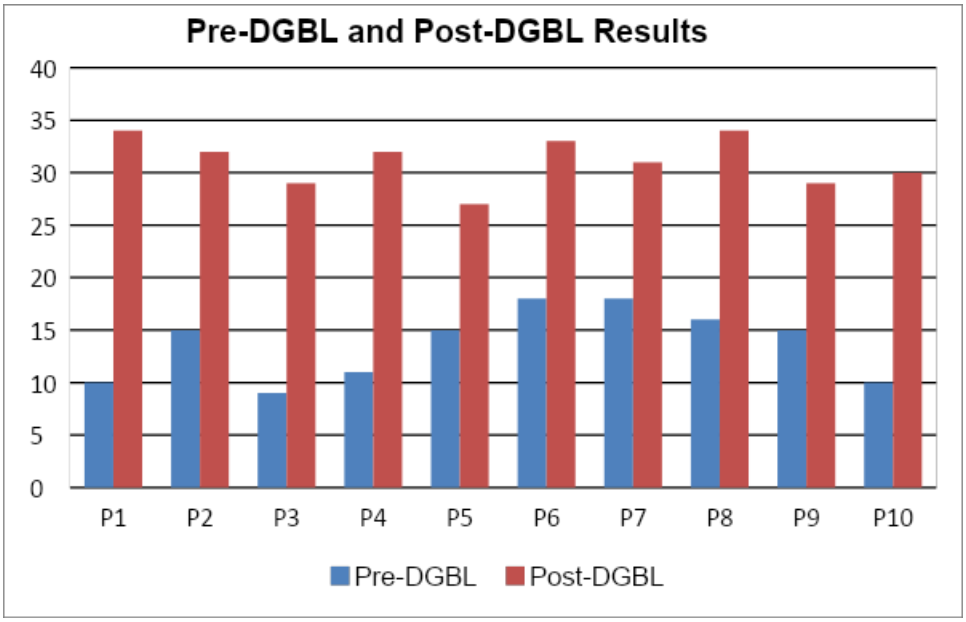


Figure 4.2: Pre and Post DGBL results

The overall digital post-DGBL scores achieved by participants were impressive. Based on the DGBL result improvement, all the participants benefited from rewards and reinforcement interventions during DGBL. The participants were motivated to foster better digital game performance that positively impacted on their academic performance in the Natural Sciences and Technology subject. The findings confirm that the participants' academic self-efficacy improved as a result of DGBL. Academic self-efficacy, according to Bandura (1997:37), is a belief or conviction that one can achieve a specific goal or attain a particular outcome on a specific academic task. High self-efficacy will positively affect performance and, in turn, good performance will enhance one's self-efficacy (Cheng et al. 2019:3). The findings correspond with a study by Meluso, Zheng, Spires and Lester (2012:501) which revealed a significant increase in the science self-efficacy of 5th graders after playing a digital mathematical game. This improvement includes those that are not academically strong.

4.3.2 Researcher's DGBL observations

The researcher conducted DGBL observations on each of the seven digital games played by each sampled participant. The observations focused on participants' behaviours (positive or negative) during the DGBL sessions. The observations results are presented according to the order in which the digital games were played by the participants: *plant labelling; changes of state; natural water cycle; properties of materials; paper house; food chain; and ear labelling.* All the games were in line with and supported the Grade 4 Natural Sciences and Technology curriculum.

The observations of the participants during the first game - ***plant labelling*** were as follows: The participants had mixed feelings and emotions when they commenced the digital game-based learning process (DGBL). The researcher observed that most of the participants were tense and uncertain when the DGBL started. Few learners were relatively confident when they started DGBL. Being tense and uneasy implies low self-efficacy as learners who possess high self-efficacy envision success and provide positive guides for performance. Learners with a low self-efficacy according to Bandura (1993:118) are uncertain about many things and often imagine failure. They believe that they don't measure up to some standard that others learners meet and would try as much as possible to avoid difficult tasks. The researcher observed that some of the participants felt that they didn't deserve to be in the computer lab playing games as they felt tense and uneasy.

The observations noted during the ***change of state game*** revealed that there was slight improvement of the learners' DGBL confidence during the second digital game. A few participants were asking the ICT teacher for assistance during game play. The confidence was slowly building up. Some participants were excited after getting the answers correct and could be heard saying "*yippee! I won! yay, yes".* Other participants were raising their hands up in the air out of excitement. These expressions show that the participants were mastering their game playing and were getting rewards. The rewards they were getting during play had meaning to the participants and made them to put extra effort. Kim et al. (2017:626) state that many studies "find that digital games have strong potential to enhance students' learning by increasing motivation". According to Plass, Homer and Kinzer (2015:260) motivation is the most frequently cited aspect of games, especially when rewards are included.

The observations during the third digital game - ***natural water cycle*** showed that the majority of participants were quiet and focused during game play. The researcher observed that the game was a bit challenging and heard Participant 6 saying that "*yoooh this game is hard'*. Experiencing failure as the researcher observed is equally important in that it builds resilience where failures or setbacks are considered as learning opportunities. Bandura (1994:71) states that individuals with high assurance in their capabilities approach difficult tasks as challenges to be mastered rather than as threats to be avoided while individuals who doubt their capabilities shy away from difficult tasks which they view as a personal threat. Those participants who were doing very well and

getting higher points could be seen smiling and clapping hands for themselves. The digital game experience helped the participants to learn the value of persistence. Persistence helped in developing their academic self-efficacy.

Observations during the fourth digital game – ***properties of materials*** indicated that the participants were showing signs of confidence the more they were being exposed to digital games related to particular Natural Science and Technology learning areas. They were taking less time to complete the games as compared to the first time they started playing the games (self-competition) thus increasing their academic self-efficacy. Participants were involved in self-competition as the digital games has a competitive aspect. Competition in DGBL, according to Hwang & Chang (2015:36) could be linked to improved learning as it stimulates the interest of learners and increases the efficiency of the learning process. The participants were striving to finish the digital game in less time i.e trying to beat their previous scores. They were trying to learn the science concept in a short period of time. New concepts become easier to remember when embedded in digital games.

In the fifth game – ***paper house***, the overall impression of this game was characterised by successful game performance, characterised by confidence, pride, commitment, motivation and persistence. At this point in time, the number of learners improved confidence and positive emotions showed improvement. Success in previous digital games was a source of learning motivation at this stage of the digital games. Participants had feelings of excitement written all over their faces as they were showing of their end products to the ICT teacher and the researcher. The researcher heard some of the participants saying "*look at house, look at my house it's the best!* "they went on further to say "next *time I'm going to make a car!"*. This was observed by Byrne et al. (2014:409) who argue that learners with a high degree of academic self-efficacy set themselves challenging goals to which they are dedicated and also have an interest in academic activities. The researcher observed that success was building a strong belief in participants' academic self-efficacy. They were setting goals for themselves, which is a sign of self-efficacy. Those with a strong self-efficacy believe they can accomplish even difficult tasks that are more challenging.

The observations of the participants during the sixth game – ***food chain:*** Most participants were responsive, interested, had strong convictions, and positive emotions about the game. Only one participant struggled to complete the game, while another received strong reassurance from the

teacher to complete the game. This implies that the more the digital games played by the learners the better they became confident in their performance. The above view was supported by Byrne et al. (2014:410) who stated that being able to strategize, control and assess personal learning as well as being able to adjust abilities are some of the characteristics of having a high self-efficacy. The participants' academic self-efficacy was improving with each game played. Learners who have a high self-efficacy according to Bandura (1993:131) are able to envisage themselves effectively completing tasks by providing their own positive guides and supports (i.e. they expect success). The participants' academic self-efficacy was improving as a result of DGBL with rewards systems.

The observations noted during the ***ear labelling game*** revealed that all participants were determined to complete the digital game and achieve good results. There was evidence of persistence, confidence, excitement, remarkable keenness and accuracy. The participants 2, 5 and 8 showed high degree of independence and participant 7 displayed competitive mood. The overall learner performance in the last digital game demonstrated that the learners' better understanding of Natural Science and Technology through DGBL process. Some participants could be heard saying that "now *I know how the ear works"*. This showed that the games taught and simplified concepts. A similar observation was made by Kellinger (2017:17) who acknowledges that digital games provide real world contexts which enable learners to relate with and develop better understanding of concepts which increases the likelihood of skills and knowledge transfer to real world situations.

4.3.3 Research Diary

The researcher observed and noted that the majority of participants were excited when they entered the computer laboratory, while few participants lacked confidence when they entered the computer laboratory. Some participants were nervous and tense during computer game playing sessions of different games. The participants displayed mixed emotional feelings of hesitancy and excitement. Some participants were enthusiastic and had pride written all over their faces as they mastered the computer games. Bandura (1994:71) observed that successes build a strong belief in one's personal efficacy. The researcher further noted that only three out of ten participants had used a computer to play games before. This revealed that most participants had low levels of computer literacy which meant that some participants needed assistance more than others when playing the digital science games. Some participants were pleased when they were praised by

the researcher and other participants. Others were encouraged not to give-up and keep trying to play challenging computer games. Oral praises that communicates faith in a person's abilities according to Usher & Urdan (2016:77) can raise self-efficacy while critical appraisals can lead to self-doubt. One participant approached the researcher after a DGBL session and expressed happiness with their DGBL results. Some participants had strong need for assurance and individual attention as they had low faith in their computer game skills. Others tried to avoid the computer games they perceived to be challenging as observed by Bandura (1993:133) who postulates that they will be stressed when they face difficult tasks. There were participants who shared their game experiences with other learners during break time. The participants gained more confidence as they played more computer games. They increased positive emotions in appreciation of better computer game achievements.

The overall impression observed during the early digital games such as plant labelling, change of state and natural water cycle revealed mix participants' feelings as few participants expressed confidence, excitement and enthusiasm when they got involved in DGBL, while the majority expressed negative emotions such as being nervous, insecure, and uncomfortable and lacked confidence. As the participants increased the number of games played, positive emotions expressed increased. The participants' positive behaviours were evident during digital games that include properties of material, house paper and food chain. The majority of participants were excited, inquisitive, and persistent. Despite temporary setbacks in some previous games some participants were persistent. Snow (2016:6) points out that the DGBL methodology assists learners to acquire and test skills in a favourable learning environment where failure is viewed as a chance to level up and improve performance. Few participants expressed negative emotions by expressing doubts, confusion and even lack of confidence. Computer games could be an effective tool to facilitate learning. Sung & Hwang (2018:120) also observed that they improve learners' higher order thinking and promote learner's interactions with learning systems.

4.3.4 Participant DGBL Journal

The DGBL journal results were based on participants' self-reporting of their experiences after completion of each respective digital game linked to a Natural Science and Technology topic. The participants were expected to express how they felt after completing every digital game. They were also expected to share their experiences and thoughts during the digital game sessions. The frequencies of their responses were captured, classified and presented according to

Bandura's Academic Self-efficacy dimensions: mastery experiences, social persuasion, vicarious experiences by social models, and somatic and emotional states.

Number of participants out of a total of 10 participants playing 7 games, with a maximum response of 70*		**Option selected on page 1 of DGBL journal**	**Bandura's four main sources of self-efficacy beliefs**
Response number	Percentage		
29/70	41.4%	Felt very good	Mastery experiences
29/70	41.4%	Felt like a winner	Mastery experiences
49/70	70.0%	Felt confident	Mastery experiences
65/70	92.9%	Felt proud	Mastery experiences
60/70	85.7%	Eager to play more games	Mastery experiences / Social persuasion i.e. persuasion by others
47/70	67.1%	Teacher praised me	Social persuasion i.e. persuasion by others
53/70	75.7%	Friends mastered the game, so can I	Vicarious experiences by social models
61/70	87.1%	Game helped to understand Science better	Mastery experiences
58/70	92.9%	I persevered	Mastery experiences
62/70	87.3%	Good mood – did well	Somatic and emotional states

Table 4.3: Influence of DGBL on academic self-efficacy

The DGBL journal observations of the five ***mastery experience*** revealed that participants academic self-efficacy improved as a result of DGBL with reward systems.Mastery experience in this study relates to the ability and confidence in solving problems during DGBL. Performing a task successfully increases one's self-efficacy. The participants experienced successes during DGBL where they had fun, persevered, gained confidence and gained an understanding of the

Natural Sciences and Technology subject. Bandura (1999:28) emphasises that as long as people believe that they are able to produce desired effects by their actions, they will persevere in the face of problems to achieve success. Through DGBL participants were able to prove that they are capable of acquiring new skills. Success forms a strong belief in one's personal efficacy while failures undermine it, particularly if failures happen before a sense of efficacy is firmly established (Bandura 1997). The DGBL journal of participants' also had responses as follows:

- Eager to play more games (85.7%); and
- Teacher praised me (67.1%).

This implies that the participants enjoyed DGBL such that they wanted to play more. Most participants expressed sadness when it was time to go home as they wanted to keep on playing. When they were praised by their ICT teacher, they did very well and improved their game-play. The participants were capable of engaging in goals when they felt validated and empowered. Bandura (1994:n.p) states that people who are verbally persuaded that they have the competences to master given activities, will try hard to succeed.

According to Bandura's self-efficacy, the sources of ***social persuasion*** include the participants' eagerness to perform an activity and responding to positive comments made by the researcher or ICT teacher. Genuine and realistic encouragement was given by the ICT teacher. The participants who felt like giving up during play were encouraged by the ICT teacher and they improved. When learners are supported and belief in them is expressed, they feel empowered and begin to set higher goals for themselves. When learners are verbally convinced that they have skills to master given activities, there are likely to put in more effort and sustain it rather than when they have self-doubts.

The participants' rating of the option: Friends mastered the game, so can I was 75.7%. The number of participants who acted on **vicarious experiences** by social models was very high. The participants were able to improve their performance by emulating their peers who performed well in some digital games. When the participants saw their peers getting higher scores, they had to put more effort in order to get higher scores and shorter time in game play. The better performers served as good social models that motivated other participants to excel in the quality of their performance. Participants displayed an eagerness to showcase their progress to both their peers and the researcher. This was supported by Bandura (1977) asserts that seeing others

similar to oneself thrive by continued effort increases observers' beliefs that they too have the abilities to master the similar activities.

The participants' responses to: Good mood – did well was 87.3% ***(somatic and emotional states)***. The majority of participants stated that they played very well when they were in a good mood. Those who were experiencing anxiety were not performing well. This implies that participants who were able to manage anxiety when experiencing thought-provoking situations improved their sense of self-efficacy. Bandura (1993:133) was the first to note that when individuals have a high sense of coping self-efficacy, they are bold when taking on taxing and threatening activities. This may be due to the fact that they are at peace when they face difficult activities in contrast to those learners with a low self-efficacy who would be stressed when they face difficult tasks. The participants played well and their positive mood boosted their confidence in their skills.

4.3.5 Participants' summative assessment of Grade 4 Natural Sciences and Technology

The summative assessment of each participant in Term 1 was compared to the average of the participant's summative assessment in Terms 2 and 3.

Participant	Term 1	Term 2	% increase	Term 3	% increase
1	12	16	33.3	21	75
2	10	15	50	19	90
3	9	14	55.5	17	88.8
4	7	15	114.2	18	157.1
5	9	17	88.8	20	122.2
6	6	12	100	15	150
7	8	15	87.5	17	112.5
8	11	14	27.2	21	100
9	6	12	100	16	166.6
10	8	10	25	15	87.5

Table 4.4: Comparison of summative assessment for Term 1,2 and 3

The presentation of results in table 4.4 clearly represents the differences between the summative assessment results of Terms 1, 2 and 3. Participants had low academic self-efficacy as shown by

their assessment performance in Natural Sciences and Technology. Participants did not perform well in their Natural Sciences and Technology assessment in Term 1 where most of them got below average marks. The tests for Term 1, 2 and 3 were all out of 30 marks. According to the National policy pertaining to the programme and promotion requirements of the National Curriculum Statement Grades R-12 (NPPPPR) (2013:16) learners must obtain a moderate achievement of 40% or more in Natural Sciences and Technology of which most of the participants did not achieve the minimum requirement in Term 1.

The percentage increase was calculated as follows:
% increase = Increase (final – initial) ÷ initial Number × 100.
For example, participant 1: % increase = (16-12) ÷ 12 x 100 (see table 4.4)

The above table shows that there was a percentage increase in subject mastery of participants in Natural Sciences and Technology in both Term 2 and 3 respectively. The participants did not perform well in Natural Sciences and Technology in Term 1. All the participants benefited from the DGBL intervention as the games provided the right levels of challenge for them to attract their attention. Conquering a challenging subject, according to Bandura (1993:134), has an impact on academic enthusiasm and attainments. DGBL provide the right level of challenge for learners to attract their attention and ensure that they learn something from its experience. Furthermore, Zhang (2014:48) stipulates that learning success, behaviour modifications, assessment performance and setting goals are connected to academic self-efficacy.

4.4 THEMATIC ANALYSIS

As indicated in chapter 3, the researcher followed the model of thematic analysis of Braun and Clarke (2006) as a guiding framework for the analysis to produce an insightful data that answered the research question. Four themes emerged from the data collected. The themes from the DGBL journal, researcher's diary, observations were examined and cross-referenced with the themes generated from the interviews. To ensure the accuracy of the transcriptions, the researcher attended to the audio-recordings of the interviews several times, as recommended by Stuckey (2014). These themes were identified as the rich and detailed account of learners' perspectives on the exploration of how DGBL with reward systems contribute to the development of academic

self-efficacy in Grade 4 learners. The data from interviews consisted of interview transcripts. The interviews were audio-recoded and transcribed verbatim to capture the participant's viewpoints. Throughout the interviews and data analysis process, all assumptions and preconceived ideas held prior to conducting the interviews were noted in the researcher's diary. This ensured that biases resulting from past personal knowledge and theoretical knowledge obtained from the literature were noted and focus was placed solely on the described experiences, discussion of each theme, together with sub-themes and categories of subthemes. Each theme is explained and substantiated with verbatim excerpts from the interviewees' transcripts.

Theme	Sub-theme	Category	codes
1. Learners' perception of DGBL	**1.1 Mastery experiences in DGBL**	**1.1.1 Enjoyment**	**Fun, Exciting Helpful, Good and nice**
		1.1.2 Self-confidence	**Faster in my work, Stimulate my brain, Self-confidence, Feel comfortable**
	1.2 Rewards and performance goals	**1.2.1. Games improved science understanding**	**Willing to do better, my mother is happy, I can now manage, I passed, am now good at Science**
		1.2.2. Winning mentality	**Winning mentality, exciting, felt good, happy was winning, master everything**
		1.2.3. Mastery of other subjects	**Will be better in other subjects, will improve in Maths, I believe in myself, will achieve, perform better**

2	Learners' perception of social support	2.1 Teacher verbal persuasion 2.2 Peer verbal persuasion	2.1.1 Teachers' praises	Teacher encouraged me to do better, was about to give up, was given instructions, helped me, felt there was nothing to stop me
			2.2.2 Parents' encouragement	My mom wished me luck, mommy was very happy, parents happy
			2.1.3. Peer' support	Felt good and happy, my friend praised me, was really happy, come on you can do it.
3	Learners' perception of peer mastery of games	3.1 Perception of friend's performance	3.1.1 Friends did well	If they can do it, I can also do it, was happy for them, I am going to do this, I felt like I also had to win, I felt more challenged to do better
			3.1.2. Emulating friends' performance	I thought was a winner and nobody can beat me, I was also going to master the games, was going to finish the game fast,
4	Learners' perception of emotions	4.1 positive emotions on performance 4.2 Negative emotions on performance	4.1.1. Good mood	My feeling was telling me that I should win, was happy, feeling good and I won, I felt happy and influenced to do better.
			4.1.2. Frustration	Wanted to quit, was making too many mistakes, was bored, was angry
			4.1.3. Anxiety	Bad performances, nervous, sad, scared they would laugh at me

Table 4.5: Summary of themes, sub-themes and categories

Emerging themes from the thematic analysis

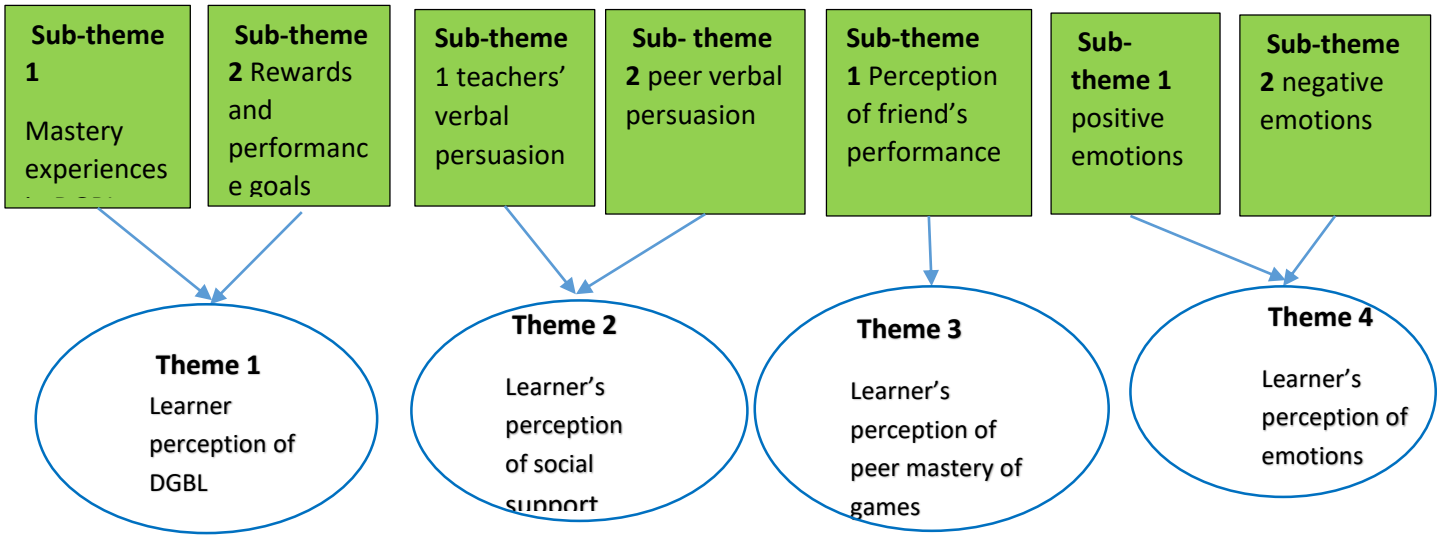


Figure 4.3 1: Themes. Sub-themes and categories

4.4.1 Theme 1: Learners perception of DGBL

All the participants' interview results as well as the summative assessments revealed a marked improvement in Natural Sciences and Technology after the DGBL intervention. This implies that there was an increase in their academic self-efficacy after the DGBL intervention. This was also observed by Kim et al (2017:626) who indicated that digital games have strong potential to enhance learners' learning by increasing self-confidence and intrinsic motivation. The participants were able to relate problem solving in DGBL to real life situations which enhanced their Natural Sciences and Technology subject performance. The mastery experiences were predominant in self-efficacy beliefs among all the participants who took part in the case study. Successful experiences they got from DGBL increased their academic self-efficacy beliefs. There was evidence of new Natural Sciences and Technology concept learning, improvement of participants' current performance and intrinsic desire to learn Natural Sciences and Technology content by participants. *"The games are fun; they taught me about science,* was Participant 5's response after being asked about their DGBL experiences. Participant 2 said, "*Yes, I am very happy. In one of these tests, I got 27 out of 40 and I am willing to do even better*." Participant 4 explained, "*Yes, I am now happy because I was struggling in term 1*." The participants'

approaches and successes in DGBL were indicative of the role of academic self-efficacy in handling learning of challenging knowledge. This view is shared by Wang and Neihart (2015:65) who reiterate that academic self-efficacy is linked with being the best in achieving goals or having an innate interest in doing things and being happy with the outcomes.

Sub- theme 1.1: Mastery experiences in DGBL

The overall participants' game experience mainly confirmed Bandura's mastery experiences as a key source of self-efficacy beliefs. The participants experienced confidence, excitement and victorious feelings during DGBL. The researcher observed that DGBL provided the right level of challenge for learners to attract their attention and ensured that they learned something from the experience. Most participants were able to master the games and solve problems during DGBL. They experienced success during play which improved their academic self-efficacy. DGBL as the researcher noticed, enhances learning by increasing self-confidence and intrinsic motivation. It fosters higher order thinking and influences participants' personal real life perception. The DGBL experience helped the participants to learn the value of persistence. The results correspond with Bandura (1994:73) who deems motivation as one of the major psychological processes that activates self-efficacy. There were clear affirmative answers from the ten participants that they were convinced that their performance in Natural Sciences and Technology was a success. The performance was substantiated by the post-DGBL performance (see Table 4.2 and Figure 4.2). There was clear evidence from the study that most participants had gradual improvement of performance after progress completion of the digital games.

Sub-theme 1.2: Rewards and performance goals

Motivating learners is essential in developing their skills and make them reach their goals.
Giving rewards for achieving goals to individuals can increase effort and reinforce goal commitment. The rewarding aspects of DGBL provides a sense of satisfaction. Rewards for the DGBL were in form of stars, points and positive feedback. The participants were competing with themselves with regards to the time taken during game play. The competitive aspect of digital games gave rise to the experience of success in the learning process when the participants were attempting to get higher scores thus motivating them to put in extra effort. The researcher observed that the participants were showing each other their points and were boasting of shorter game completion time. The researcher observed and also noted in her diary that the participants were happy when they were moving on to the next level during DGBL as it meant that they were getting the science concepts correct. Shariza and Nasir (2020:239) supported the above

statement by stating that learners feel content after getting a reward for recognition of good work. This corresponds with the view that learners appreciate if they are rewarded for doing excellent work. Although this may seem like it's not true, it does however speak to a wider issue that has overwhelmed the educational system in general. Below is the statement that was noted by the researcher in the diary.

Research diary comments

Learners were excited as they mastered the game. Happiness was written all over their faces. The researcher had to caution them as some of them were clapping hands for themselves out of excitement. They were not happy when they were asked to pack their things as it was time to go home.

Reflection 1 (27 June 2021)

The findings confirm the significance of rewards as alluded by Plass, Homer and Kinzer (2015:260) who reiterated that when rewards are applied in form of scores or stars based on game performance, they motivate learners to stay engaged over long periods of time

a. Enjoyment

The researcher observed that the benefits of DGBL like engagement and motivation are too compelling to ignore. In addition, she also noted that DGBL lead to positive feelings as participants were relaxed and looked happy. When learners feel good about themselves and their achievements, their self-confidence builds up. DGBL encourage learning through practice, repetition, making mistakes and experimenting which is different from the traditional way of learning. The results reflect that eight out of ten of the participants had an overall exciting and fun experience as they acquired Natural Science and Technology knowledge upon successful completion of the seven games. The participants' enjoyed the experience of DGBL and indicated that*: "I enjoyed and it was very helpful.", in addition another participant revealed that "It was fun; I couldn't wait to play when I saw the games."*

The learning experience through computer games was exciting, stimulating and encouraging. The findings confirm that when learners are led to discover that learning can be fun and emotionally satisfying, they will work to their full potential. As they were progressing to the next level of the game, it gave them a sense of achievement. It made them to persevere so that they

could move to the next level. The researcher contended that when Grade 4 learners are led to discover that learning through games can be fun (Campos & Moreira 2016:463-468) and emotionally satisfying, they will work to their full potential. Participants claimed that they had fun while learning and it appears that the fun aspect of DGBL assisted in the retention of information.

b. Self-confidence

In response to the question regarding how the participants benefited from playing the games, the majority of participants shared that they developed a better understanding of the Natural Science and Technology subject and are no longer afraid to ask their teachers questions. DGBL allowed the participants to set specific tasks and allowed them to work through obstacles to achieve those tasks. The researcher observed that the DGBL experience provided a sense of satisfaction for the participants by reinforcing their motivation whenever they accomplished a task. Participants made the following comments with regards to the Natural Sciences and Technology subject: *"They helped me to be good in science…",* Participant 7 regarded the use of games as stimulating to the mind which supported learning Natural Science and Technology and indicated that *"They helped to stimulate my brain…"* Participant 7 went on further to say that *"I started with low confidence and began to feel comfortable, and ended up doing great."* Playing the digital games improved their self-confidence and quality of performance.

The participants mastered and understood the Natural Sciences and Technology concepts which made them achieve their summative assessments. The findings support Bandura's view that conquering a challenging subject has an impact on academic enthusiasm and attainments (Bandura 1993:134). The findings suggest that DGBL promotes the development of academic self-efficacy. Observations further indicated that majority of participants had impressive performances showing excitement, good mastery of game skills and pride, and remarkable keenness and accuracy. There were some participants that demonstrated persistence despite facing temporary setbacks. The participants were inquisitive and willing to learn the digital games.

c. Games improved Science understanding

Liu and Chen (2013:1045) indicated that "acquiring scientific concepts can be made easy by the use of games during lessons". This corresponds with the results which showed that all participants expressed that their Natural Sciences and Technology performance had improved since Term 1. The participants' desire to win or complete the games could motivate them to study subject related materials. In the interviews, some participants reported that they had more success in

understanding concepts during DGBL. Four participants indicated that their Natural Science and Technology marks improved and the performance was impressive.

A participant expressed happiness that the Natural Science and Technology mark improved, but the improvement was not significant. The participant shared that: "*Yes, but not that much!".* Obviously, the analysis of the learners' responses shows that much work still needs to be done to ensure unilateral success of DGBL. The participants showed an improvement in Natural Science and Technology as shown in their term 3 summative assessment which also confirms that their academic self-efficacy improved as a result of DGBL with reward systems. Below is the statement that was noted by the researcher in the diary.

Research Diary Comments

Learners brought their books to the computer lab today and were showing me their work which have improved. I noticed that even the handwriting has changed for some participants.

Reflection 2 (4 August 2021)

DGBL somehow improved their understanding of concepts they perceived as challenging before. It made the concepts easier as the digital games promote communication, experimentation and exploration. Dawes, Nicholls and Dore (2014:3) indicated that the "intrinsic interest of science is in thinking through and resolving the puzzles which are the ways the world works". The participants were acquiring skills like problem solving and analytical skills without fear of failure or being judged by other learners. The skills acquired are very important in the learning of Natural Sciences and Technology. It is thus apparent that DGBL, in the view of the participants, was successful in adding value to the learning process.

d. Winning mentality

In response to an interview question what did it mean to you when you mastered the game? The results confirmed what mastering the digital games meant to them i.e winning mentality. Most participants expressed mastery experiences that include feeling good, happy being a winner and confident when they mastered the games. Seven out of ten participants showed excitement and felt good, and expressed that *"It meant that I learnt more science and I was happy".* Another *participant explained "It meant everything, and I was so happy that I was winning the game."* Participants displayed a winning mentality as a result of DGBL. The

researcher observed that the participants' mindset was focused towards growth and success. Learners who are confident in their abilities and who have a high self-efficacy will not give up easily while those with a lower self-efficacy may not be able to withstand the pressure and give-up easily in their academic endeavours. Thus, high self-efficacy will positively affect performance and, in turn, good performance will enhance one's self-efficacy (Cheng et al. 2019:3). The researcher observed that participants with a winning mentality have a high self-efficacy. These learners can manage their own learning by setting goals for themselves and understanding learnt concepts. Learners have a tendency to exert more determination regarding their studies when they have interest and enthusiasm for the subject. Research diary corresponds with the findings as participants were proud of their achievements and showing off the rewards.

Research Diary comments

Learners were moving up and down showing each other their reward stars. The I.T instructor had to call them to order.

Reflection 5 (16 August 2021)

e. Mastery of other subjects

In response to a question about their feelings regarding other subjects, the majority of participants were hopeful and confident that they will perform better in other subjects. Eight participants indicated that they will improve in other subjects based on the confidence gained from winning digital games. As one participant put it, *"I think I will be better in other subjects because of the computer games" another participant went on to say that "Yes, I will be able to improve because I believe in myself".*

Bandura (1993:133) supported the study findings by advocating that learners with high academic self-efficacy have confidence in their capabilities to master academic subjects and these beliefs aid as predictors for future academic achievements. When answering question 3 (see appendix L), Participant 1 shared that game-based learning created the belief that learning anything could be possible in future supported by the statement: "*It made me feel like I could master anything"*. Participant 10 however, indicated that apart from mastery of science games, performance in other subjects was not impressive and said, *"I am still struggling".* This statement provides a clear indication that more work still needs to be done to improve in other subjects.

The participants' journal results confirm that participants changed perceptions about their personal subject learning ability during the DGBL process. The participants' self-efficacy and self-belief was enhanced through improved game performance. The observations made during the digital games revealed that majority of participants expressed excitement, happiness, confidence and enthusiasm that contributed to their game performance. Cheng, She and Annetta (2015:234) seemed aware of the effects of DGBL and suggested that difficult scientific ideas that learners find hard to understand can be taught using the DGBL.

Research diary findings corroborated that majority of participants were enthusiastic and had pride written all over their faces as they mastered the computer games.

Research Diary comments

Pride was written all over their faces as they were getting rewards during DGBL. Most of them did not need help in setting up as they were quick to log on their computers. The confidence is improving each day. They don't wait to be called anymore: they just go straight to the computer lab to wait for me there…

Reflection 3 (11 August 2021)

4.4.2 Theme 2 Learner perception of social support

During the post-DGBL implementation, the participants received encouragements and praises from the teacher and their peers. From theme 2 emerged the following sub- themes: Teacher verbal persuasion and peer and parental verbal persuasion. Bandura's self-efficacy report asserted that people could be persuaded to be certain that they have the skills and abilities to do well.

4.4.2.1 Sub-theme 2.1 Teacher verbal persuasion

The impact of social persuasion from the participants' teacher was very positive among most learners. In line with the research findings, Usher and Urdan (2016:77) suggest that if social support and guidance are presented in the early stages of learning that result in a sense of self - efficacy, it can result in sustained personal change. Positive feedback from the teacher assisted doubtful participants and those who were easily distracted. Receiving verbal reassurance from others assist people overcome self-doubt and instead focus on giving their best effort to the task

in hand. Few participants expressed lack of confidence when playing digital games and others exhibited disruptive behaviours. The ICT teacher had to provide extrinsic rewards in form of support through encouragement and reassurance to derive effective game performance. The participants responded positively to the ICT teacher's approvals and reinforcements.

Research Diary comments

The natural water cycle game is challenging and requires concentration and perseverance. Some of the participants were struggling and wanted to stop. The ICT teacher encouraged them that they can do it and they ended up doing well.

Reflection 4 (27 May 2021)

Participants' interview responses were aligned to social persuasion or persuasion by others; another facet of Bandura's self-efficacy beliefs. They participants indicated that they were encouraged by positive comments from the researcher and ICT teacher to attain high quality performance. One participant shared that receiving praises developed an invincible feeling when playing digital games. The participant was directly quoted as saying: *"I feel like there was nothing to stop me when playing the games".*

Participants showed that when they are encouraged or praised they do better. This also confirms the findings by Horsburgh and Ippolito (2018:6) who indicated that learners value being supported by a role model. This implies that learners value encouragements given by those in position of authority. Kaymakamoğlu and Atmaca (2016:38) observed that learner's beliefs are affected by the learning context which entails other people who are around when learning takes place. Findings from this study suggest that encouraging learners that they can succeed at a task can lead them to believe that they can learn skills and accepted ways of behaving a particular context (Horsburgh & Ippolito 2018:2). Participants were encouraged when they felt like giving up as they felt that the game was challenging. They soldiered on and did not give up.

4.4.2.2. Sub-theme 2.2 Peer and parental verbal persuasion

During the post-DGBL implementation, the participants received encouragements and praises from their peers and parents at home. The verbal persuasion from their peers brought change to their attitudes which resulted in successful game-playing. The participants responded positively to the positive applauds from other participants. Some participants would cheer others and would be heard saying "*come on! Come on you can do this!"*. Participants indicated that praises

from their peers made them feel special and excited during the DGBL process. *"When my friend praised me, it meant everything to me. I was happy that I won."*

Verbal encouragement according to Bandura (1977:198) is aimed at raising outcome expectations. Participants were convincing each other that they had the ability to complete the games successfully. Usher and Urdan (2016:77) added on to say that if social support and guidance are presented in the early stages of learning that result in a sense of self -efficacy, it can result in sustained personal change.

Research Diary comments

The natural water cycle game is challenging and requires concentration and perseverance. Some of the participants were struggling and wanted to stop. The ICT teacher encouraged them that they can do it and they ended up doing well.

Reflection 4 (27 May 2021)

A participant remarked that encouragement received from a parent improved their Natural Sciences and Technology examination performance. The participant said, *"I wrote exams and passed when my mom wished me good luck".* The view is supported by Ren & Edwards (2015:615) who indicated that children whose parents convey the message that their children can accomplish certain goals, internalise these goals. The praises yielded different positive experiences that were predominantly attributed to digital game performance improvement. Chen (2015) in Zong et al. (2018:345) observed that children strive to outperform others in competitive environments to repay their parents' rewarding involvement.

4.4.3 Theme 3: Learner perception of peer mastery of games

The mere fact that learners saw their peers performing well, achieving higher game scores in shorter times encouraged others strive to reach performance, if not better game scores at shorter times. From theme 3, emerged the following sub-theme: perception of friends' performance.

4.4.3.1 Sub- Theme 3.1 Perception of friend's performance

Most of the participants' interview answers confirmed that the participants were positively influenced by their friends' performance. The responses were associated with vicarious experiences propounded in Bandura's self-efficacy theory. The friends' good game performance

served as an external motivator for the participants leading them to emulate their friends. This implies that observing others succeeding at a task can strengthen beliefs in one's own abilities. The findings confirmed Usher and Urdan's (2016:76) view that apart from interpreting their own experiences, individuals have a tendency of observing the actions of others and make inferences about themselves. The participants benefited from the inspiration they obtained from success game completion by their friends. Usher and Urdan (2016:76) further contend that models can also expose onlookers to more effective ways of doing things thus raising self-efficacy. The results corroborate with Bandura's (1993: 121) proposition that people's performances are influenced by their peers whom they compare themselves to.

The responses to the question about how the participants' friends mastered the games revealed that some participants were challenged and encouraged by their friends to perform better, while others were marveled at for their friends' performance. as one participant put it, *"I said, if they can do it, I can also do it".* The researcher observed that learners persevered when they saw that their friends were doing well in DGBL.

Research Diary comments

The participants were looking at each other as they were playing like observing them. I could see that others were admiring the way others were playing.

Reflection 6 (24 June 2021)

4.4.4 Theme 4 Learner perception on emotions

Individuals use their *somatic and emotional states* or bodily feelings and moods when formulating their self-efficacy beliefs regarding certain behaviour. Individuals can measure their degree of confidence by the emotional state they experience as they perform an action. Anxiety and fear of an activity can affect self-efficacy negatively which can lead to failure to perform the dreaded activity. Some participants experienced emotional states like happiness, sadness, anxiety and fear.

4.4.4.1 Sub- Theme 4.1 positive emotions on performance

The participants' journal results indicated that learners who performed well in the digital games, shared that they had positive emotions. Bandura (1999:30) asserts that people rely partly on their somatic and emotional states in judging their abilities for instance positive emotions boost

confidence in their skills. For example, positive mood improves self-efficacy while bad mood reduces it.

The participants, with regard to the impact of their feelings on digital game playing, revealed that they had different emotional experiences. When they were in a good mood, they did very well. One participant made the following statements*: "My feelings were telling that I should win so that I wouldn't become sad".* Another participant went on to say*, "I felt happy and that influenced me to do much better and knew I could do anything as long as I put my mind to it".*

Positive emotional behaviour was evident in findings in the current study where participants made gradual improvement in digital game performance regardless of challenges faced when playing the games. From the participants' perceptions, it is clear that feelings played a significant influence on participants' overall performance in the playing and success of digital games. Findings by Bandura (1993:133) corroborate that when individuals have a high sense of coping self-efficacy, they are bold when taking on taxing and threatening activities. This view was true regarding the challenges faced by some participants during their digital games that ultimately had successful performance.

4.4.4.2 Sub- Theme 4.2 Negative emotions on performance

During the first three digital games, observations showed that most participants expressed insecure, nervous and uncomfortable behaviours. The findings concur with Bandura's (1993:118) assertion that learners with poor self-efficacy visualise failure scenarios as they dwell on how things will not work and go wrong. The observation results showed frustration by few participants that almost quit, but the ICT teacher supported them to complete particular digital games. This corresponds very well with comments made in the researcher's diary.

Research Diary comments

One participant seemed bored and distant and kept on making mistakes like pressing back arrow which made them start all over again.

Reflection 7 (10 June 2021)

participants who exhibited bad mood had unimpressive game performance. low self-efficacy can lead to anxiety and distress. Observation results showed that certain participants were nervous and sad and had unsatisfactory game performance characterised by long game completion

time. These findings are consistent with those by Bandura (1999:30) that people interpret their stress reactions and tension as signs of vulnerability to poor performance.

Research diary notes showed that some participants experienced challenges when playing the digital games and wanted to give up. This was noted by the researcher in her diary below:

Research Diary comments

Heard one of the participants saying that its difficulty, I don't want to play this game anymore…….

Reflection 8 (10 June 2021)

The negative emotions experienced by the participants confirm the findings by Hung, Sun and Yu (2015: 185) revealing that challenging games are characterised by anxiety that could be reduced when the learners actively participate in the tasks with a feeling of excitement.

4.5 CONCLUSION

This chapter presented the findings of the empirical investigation of the experiences of Grade 4 learners at a school in South Africa. Four main themes and relevant sub-themes were derived from the findings through the analysis of data using the thematic analysis. The participants' academic self-efficacy was very low based on the Adapted Academic Self-Efficacy scale before DGBL, while the post-DGBL phase results reflected a significant improvement. The results attribute success in the post-DGBL phase to Bandura's self-efficacy theory four facets i.e. mastery experiences, vicarious experiences by social models, social persuasion and somatic and emotional states. The next chapter provides a summary of the study findings, conclusions and recommendations.

CHAPTER 5

FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.1 INTRODUCTION

The preceding chapter presented the analysis, interpretations and findings of research results. This current chapter reports on the summary of the literature review and the empirical investigation findings which are presented in relation to the problem statement. The conclusions of the study are based on the operationalised research results confirming the extent to which the set research objectives were achieved. Limitations and recommendations for further research are also summarised in the chapter.

To provide answers to the research problem, the primary research question was formulated as: How does digital game-based learning (DGBL) with reward systems promote the development of academic self-efficacy in Grade 4 Natural Sciences and Technology learners?
The research sub-questions were developed to assist in interrogating and answering the primary research question:

- How is academic self-efficacy deconstructed and measured?
- Which aspects or logistics are involved in the availability; terms and conditions; and acquisition and affordability of educational digital games?
- Which educational digital games with reward systems support the curriculum of Grade 4 Natural Sciences and Technology?
- How do reward systems in game-based learning contribute to the development of academic self-efficacy?

5.2 SUMMARY OF RESEARCH FINDINGS

Various findings were made during the research study, which are supported in literature and also empirically.

5.2.1 Literature findings

There is a growing body of literature suggesting that the way people think and behave is determined by self-efficacy. Relevant journals, current books and information from the internet were studied in detail in answering the research sub-questions. The literature review established that DGBL with reward systems increases learning motivation, active participation and concentration among learners (see 2.2.1 [a]). This implies that DGBL improves involvement, increase confidence in learners and promotes enthusiasm. This was similar to the findings of another study by Dickey (2011) cited in Sung & Hwang (2018:120) who acknowledges that DGBL environments are able to promote learners' intrinsic motivation as well as curiosity. DGBL afford instant rewards to the players, thus keeping them invested. This reward has meaning to learners and will encourage them to put extra effort when playing the game. The literature review findings below provide answers to the sub-research questions and each sub-research question is discussed below.

5.2.1.1 Sub-Research Question 1

How is academic self-efficacy deconstructed and measured?

Regarding how academic self-efficacy is deconstructed and measured, self-efficacy was reviewed according to the theoretical framework of Bandura's Self-Efficacy Theory (see 1.2.5) which stresses the critical role of self-beliefs in human thought, motivation and behaviour. The four main sources of self-efficacy, i.e. mastery experiences, vicarious experiences by social models, social persuasion and social and emotional states were discussed (see 2.3).

Furthermore, academic self-efficacy was also reviewed in terms of learners' beliefs in their efficacy to manage their own learning activities, to master different academic subjects and to fulfill personal, parental and teachers' expectations (see 2.4). Literature review findings confirms that learners are capable of managing their own learning and mastering different subjects when they have a high academic self-efficacy (see 2.4.1). In order to promote learners' beliefs in managing their own learning, they can be encouraged from an early age work hard and set own goals. At Grade 4 level, learners are expected to set goals for themselves, finish their work on time, do their homework and understand learned concepts. A similar view was expressed by Harding et al. (2018:6) who observed that independent and energetic learners take control and are aware of their own learning – they successfully develop strategies to plan and understand their learning.

Learners with high academic self-efficacy according to Bandura (1993:133) have confidence in their capabilities to master academic subjects and these beliefs aid as predictors for future academic achievements. Literature showed that learners who believe in their abilities see difficult subjects or activities as challenges that need to be mastered not as threats that has to be avoided (see 2.4.2.). Conquering a challenging subject, for example, according to Bandura (1993:134), has an impact on academic enthusiasm and attainments. Learners at Grade 4 level ought to have a lot of determination as they are facing various challenges which they are expected to solve. Those with a high self-efficacy may not give up easily while those with a low self-efficacy may give up easily in their school work.

The expectations that parents have with regard to their children's academic attainment, influence the children's expectations and achievement at school. Most parents want their children to excel in school and have high expectations for them. These expectations were also observed by Yamamoto & Holloway (2010:191) who argue that parental expectations generally play an important part in learners' academic accomplishment. However, when parents are too controlling, as observed by Zong et al. (2018:352) academic self-efficacy development can be negatively affected. Teachers also have expectations for their learners in terms of behaviour and academic performance and these expectations can have a strong impact on success (see 2.4.3 [c]). Higher teacher expectations based on good assessment marks lead to sustained academic achievement as the teacher would give positive feedback which increases learner confidence. The learner would exert more effort in their studies to maintain the standard thereby pleasing the teacher.

Six measures were perused to identify a suitable measure for academic self-efficacy (see 2.5). The researcher selected the Adapted Academic Self-Efficacy Scale, a subscale of the SEQ-C (Muris 2001) after identifying it as the most suitable for the current study after critically considering five other measures (see 2.5.1 - 2.5.5). The scale is composed of only 8 items, rated on a scale from 1 (not at all) to 5 (very well).

1. *How well can you get the Science teacher to help you when you get stuck in your schoolwork?*
2. *How well can you study Science when they are other interesting things to do?*
3. *How well can you study Science for a test?*
4. *How well do you succeed in finishing all your Science homework every day?*
5. *How well can you pay attention during every Science class?*

6. *How well do you succeed in understanding Science in school?*
7. *How well do you succeed in satisfying your parents with your schoolwork?*
8. *How well do you succeed in passing a Science test?*

A total academic self-efficacy score was obtained by summing across all items ranging from 8 (low academic self-efficacy score) to 40 (high academic self-efficacy score) The pre-DBGL score of the participant was compared to the post-DGBL score to determine whether there was an increase in the academic self-efficacy score. Raw scores were used in comparing the pre-DGBL to the post-DGBL scores of each learner participant. The percentage increases in individual participants' results reflected significant mark improvement.

5.2.1.2 Sub-Research Question 2

Which aspects or logistics are involved in the availability; terms and conditions; and acquisition and affordability of educational digital games?

Literature reviewed shed some light with regards to aspects or logistics that are involved in the availability; terms and conditions; and acquisition and affordability of educational digital games. It contributed to partially explore aspects or logistics —conceptualised as directives and dilemmas in chapter 2— involved in the availability; terms and conditions; and acquisition and affordability of educational digital games. The directives intended to guide when and how to implement DGBL were as follows:

a. DGBL facilitates learning, improves higher order thinking skills, increases confidence as well as promotes motivation and curiosity.
b. Provide instructional support during game play that comprises feedback, scaffolding, advice as well as guidance to select relevant information while ignoring irrelevant information.
c. Choose games with appropriate characteristics that allow for synergy between the learners' engagement and learning content. Teachers should identify opportunities for teaching.
d. Available time for digital games in the classroom should be taken into account.
e. The academic level of the learner and the learner's experience of digital games should be weighed in DGBL.
f. The teacher's knowledge of particular games to attain learning outcomes is important.

The researcher also identified dilemmas in the literature (see 2.2.2) and attempted to turn these dilemmas into guidelines (see table 2.2) for application during the DGBL implementation in this study.

5.2.1.3 Sub-Research Question 3

Which educational digital games with reward systems support the curriculum of Grade 4 Natural Sciences and Technology?

The researcher had to select a large collection of educational digital games and then matched the games with the content and concepts of the Grade 4 Natural Sciences and Technology CAPS (DBE 2011a:20-26) for the second and third term when the DGBL took place (see Table 2.3). Several collections of games were consulted in compiling table 2.3 by:

- Selecting games that enabled the learner participants to make connections and see relationships instead of learning isolated or abstract facts.
- Choosing interesting games that supported the content and concepts of the topics of the curriculum.
- Adjusting to time limits in picking short games that were not too complex.
- Matching free games with reward systems to the content and concepts.

Games like *plant labelling, changes of state, natural water cycle, properties of materials, paper house, food chain and ear labelling game* were chosen for the study (see 2.2). Rewards for the games were expressed in terms of:

- Stars
- Number of correct responses
- Higher total count after replaying and shorter times
- Positive feedback
- Points

5.2.2 Summary of empirical investigation

In this section, the researcher concludes the empirical investigation. The data was collected by participants' GDBL journals, participant observations, researcher's diary, participants' face to face

interviews and the Adapted Academic Self-Efficacy Scale, a subscale of the SEQ-C (Muris 2001) discussed and interpreted in Chapter 4. This study was grounded in Bandura's self-efficacy theory (see 1.2.5). By using this theoretical framework, the study explored how DGBL with reward systems promotes the development of academic self-efficacy in Grade 4 Natural Sciences and Technology learners. Four themes emerged from the thematic analysis of data. These themes were identified as the rich and detailed account of learners' perspective on the exploration of how DGBL with reward systems contribute to the development of academic self-efficacy in Grade 4 learners. The explanation of the themes, sub-themes and categories were enriched by verbatim quotations collected from transcribed interviews and participant DGBL journals (see 4.3.4). In addition, excerpts from the research diary and observations were also used. The subjective analysis of data was limited to a certain extent by bracketing and member checking (see 1.5.2. [d]). Intercoder agreement between the researcher and the supervisor was reached after revisiting the data frequently.

Sub-research question 4

How do reward systems in game-based learning contribute to the development of academic self-efficacy?

5.2.2.1 Theme 1: Learner's perception on DGBL

The study findings revealed that participants' successful experiences during DGBL boosted their self-efficacy (see 4.4.1.1). Participants recorded their experiences after each DGBL session. Participants expressed an increase in confidence, pride and an eagerness to play more games. The frequencies of their responses were captured, presented and classified according to Bandura's self-efficacy dimensions. The DGBL journal responses indicated an increase in mastery experiences. The mastery experiences were predominant in self-efficacy beliefs among all the participants who took part in the case study. Usher and Urdan (2016:76) postulate that mastery experiences provide a powerful boost to self-efficacy and have the greatest impact on self-efficacy. This implies that successes increase efficacy beliefs. The results of the participants' journals show that during the DGBL process, they had a positive shift in their beliefs of their Natural Sciences and Technology learning ability. These findings confirmed that the digital games helped to better understand the Natural Sciences and Technology subject (see 4.4.1.1[c]).

During DGBL learners are empowered to learn academic content through playing a game. DGBL turns learners into problem solvers and allows these learners to engage in friendly competition where they get rewards as they progress to different levels of the game. From the researcher's

games observations, the majority of participants exhibited excitement, happiness, confidence, and enthusiasm during the digital games, which contributed to their game performance (see 4.4.1.1). The participants felt enthusiastic and proud as they mastered the computer games, according to the findings of the research diary. Observations further revealed that the majority of learners had outstanding digital game performances, demonstrating excitement, mastery of game skills, pride, amazing willingness and accuracy (see 4.3.2). The interview results as well as summative assessment of all participants indicate that they excelled in Natural Sciences and Technology, and that their performance in other subjects also improved (see 4.4.1.1.). The accomplishments of the participants in the digital games revealed the importance of academic self-efficacy in dealing with difficult information learning.

5.2.2.2 Theme 2: Learner's perception of support

When people are verbally convinced that they have skills to master given activities, they are likely to put in more effort and sustain it rather than when they have self-doubts. Participants showed that when they are encouraged or praised they do better. Usher and Urdan (2016:77) elaborate that verbal praises that communicates faith in a person's abilities can raise self-efficacy, while critical appraisals could develop self-doubt. The study findings indicated that the majority of participants responded well to social persuasion from the ICT teacher. Participants who were unsure or easily distracted benefited from the ICT teacher's positive feedback and encouragement (see 4.4.2.1. [a]). This implies that learners value encouragements given by those in position of authority. After successfully completing each digital game, some participants were extrinsically motivated by accomplishment prizes from the games. When playing digital games, a few participants displayed a lack of confidence, while others engaged in disruptive behaviour. One participant's performance in digital games and Natural Sciences and Technology improved after receiving parental support and encouragement (see 4.4.2.1[b]). The compliments from the ICT teacher revealed a variety of favourable experiences, the majority of which were ascribed to improved digital game performance.

5.2.2.3 Theme 3: Learner's perception on peer mastery of games

Observing other learners succeed through sustained effort will raise the observing learners' belief that they too can succeed. Schunk (1991:208) assert that observing other learners succeeding through sustained effort will raise the learners' belief that they too can succeed. Individuals are exposed to vicarious experiences as they observe the actions of others and make inferences about themselves (Usher & Urdan 2016:76). Observing a peer succeed at a task can strengthen

beliefs in one's own abilities. Bandura (1994:72) also support this assertion by noting that it is a way of strengthening people's views that they have what it takes to succeed. The research results revealed that the simple sight of peers playing well and getting greater game scores in fewer times inspired others to try for similar, if not better, game scores in shorter times (see 4.4.3.1.). Interview results from majority of interview participants confirmed that their friends' performance had a beneficial influence on them. Bandura's self-efficacy theory would suggest that the friends' performance was linked to vicarious experiences. The participants profited from the motivation they gained from their peers' successful game completion. As they observed other participants succeeding through sustained effort also raised their beliefs that they too can also succeed. The findings confirmed Usher & Urdan's (2016:76) view that apart from interpreting their own experiences, individuals have a tendency of observing the actions of others and make inferences about themselves.

5.2.2.4 Theme 4: Learner perception of emotions

Bandura (1977:198) claims that emotional arousal is an essential data source that can influence perceived self-efficacy in dangerous situations. Moods influence self-efficacy, with happy moods increasing it and negative moods decreasing it. A positive mood can boost one's beliefs in self-efficacy, while anxiety can undermine it. A certain level of emotional stimulation can create an energizing feeling that can contribute to strong performances. The study results revealed that participants who did well in the digital games expressed happy and satisfying sentiments. The participants confirmed what Bandura describes as somatic and emotional states when they applied their positive emotions to boost confidence in their performance (see 4.4.4.1). Positive emotional behaviour was evident in the current study's findings, which showed that participants gradually improved their digital game performance despite the hurdles they faced while playing the games. The study observations revealed that few participants were apprehensive, nervous, and uncomfortable throughout the first three digital games (see 4.3.2.). These participants were frustrated and on the verge of quitting, but the teacher encouraged them to finish specific digital games. The research observations showed that individuals in a foul mood had poor game performance (see 4.3.2).

5.3 CONCLUSION

The major thrust of this research study was to explore how DGBL with reward systems promoted the development of academic self-efficacy in Grade 4 Natural Sciences and Technology learners. In this study, ten male and female Grade 4 participants of one Natural Sciences and Technology

class were sampled using intensity sampling. The data collection instruments consisted of the Adapted Academic Self-Efficacy Scale, a subscale of the SEQ-C (Muris 2001); the summative assessment of Grade 4 Natural Sciences and Technology; a research dairy with process notes and reflection; a participant DGBL journal; participant observation according to an observation schedule and impromptu and an individual face-to-face interview. A thematic analysis to organise, code and categorise data was done using the participants' encounters, conceptualisations, emotions and deliberations regarding the "Other remarks" in the Participant DGBL journal, the interviews as well as the impromptu participant observation during the DGBL sessions as recorded in the research dairy.

Bandura's self-efficacy theory provided the theoretical framework for the study. According to Bandura, self-efficacy beliefs are the most dominant and universal influence on the choices people make with regards to their goals, the amount of determination they put to a particular task as well as how long they persevere at a task in the face of failure or difficulty.

The study results confirmed that digital based learning with rewards systems promote the development of academic self-efficacy in Grade 4 Natural Sciences and Technology learners. Majority of participants excelled in their digital game-based learning and there was an improvement in Natural Sciences and Technology performances and understanding as revealed by the summative assessment of Natural Sciences and Technology in Terms 2 and 3 respectively. The development of self-efficacy in young children should be promoted as it could influence experiences as they grow older. -At Grade 4 level, learners are expected to learn more independently and assume responsibility for their actions which requires a great deal of self-efficacy. In Natural Sciences and Technology, they are assigned short research projects as outlined by the CAPS in learning the significance of evidence-based inquiry to nurture scientific thinking (DBE 2011a:8). Learners are expected to set their own realistic goals that need to be accomplished as well as independently gather information on the internet and in textbooks which require self-efficacy.

Participants received rewards during game-play in the form of points and stars as well as encouragement from the ICT teacher, parents, and peers during the digital game-based learning process which encouraged and reinforced the need to play games. The participants showed perseverance in problem solving and were turned into problem solvers during the process as DGBL fosters thinking. The ICT teacher motivated and encouraged participants to complete the

games despite encountering challenges during the games. The learners were developing an innate interest in DGBL and were happy with the results. The effective digital game performance of most participants was an inspiration for other participants as they were encouraged by their peers not to give-up during the digital games. DGBL also allowed learners to engage in self-competition as they were putting extra effort in trying to reach the highest level of the game. The few learners who struggled in digital games had low self-efficacy and negative mood and stressful experiences. Overall, the application of digital game-based learning contributed towards better understanding of the Grade 4 Natural Sciences and Technology subject as they were empowered to learn academic content through playing games. Based on the Adapted Academic Self-Efficacy scale (Pre-DGBL and Post DGBL performance) (see 4.3.1), face to face semi-structured interviews (see 4.4.), Researcher's DGBL observations (4.3.2), participant DGBL journal (see 4.3.4) and the participant summative assessments (see 4.3.5) all the participants benefited from DGBL with rewards systems.

5.4 LIMITATIONS OF THE CURRENT STUDY

It should be noted that while all the objectives set out for this study were more or less achieved, this study was not without some limitations. Although the researcher implemented measures to improve the validity and reliability of the study data and the subsequent findings, the research encountered some limitations. The generalisation of study results was limited because the research was a qualitative case study involving a small sample selected from Grade 4 learners at a particular primary school in Gauteng. Corona virus disease 2019 (Covid-19) pandemic had some effect on DGBL sessions as learners were not attending school due to lockdown. The time meant for DGBL activities was limited as teachers wanted to catch up for the time lost and wanted to use the computer lab for their own activities. The DGBL sessions were limited to 12 sessions of 30 minutes each instead of the initial 14 sessions of 30 minutes each. The researcher however, made sure that all the DGBL planned activities were done.

5.5 RECOMMENDATIONS FOR FURTHER RESEARCH

The research gaps identified from the current study present research opportunities for the direction of future studies. These gaps are as follows:

- While the current study used a single sample of learners, it would be necessary to conduct a similar study with two experimental groups so that the researcher can properly measure the entire effect of DGBL without interference from confusing variables.
- A comparative study of the use of DGBL in different contexts would help to validate the research findings and result generalisation.
- The application of DGBL in other subjects such as Mathematics and Social Sciences could improve performance in these subjects.

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5.6 CHAPTER SUMMARY

This chapter has presented the summaries of the research findings, conclusion, limitations and recommendations for future studies. The summaries were grouped into findings that arose from literature and findings that emerged from the empirical investigation. There was substantive empirical evident from the discussion supporting the use of digital games in the teaching-learning of Natural Sciences and Technology. The general performance of learners in the subject improved and excitement in learning other subjects also increased. The suggested recommendations for the current study could improve primary school learner performance, particularly for Grade 4 learners. The identified gaps have created research opportunities for future research studies.

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APPENDICES

Appendix A: Clearance Certificate from UNISA

UNISA university of south africa

UNISA COLLEGE OF EDUCATION ETHICS REVIEW COMMITTEE

Date: 2021/04/14

Ref: **2021/04/14/49851292/27/AM**
Name: Mrs I Meda
Student No.:49851292

Dear Mrs I Meda

Decision: Ethics Approval from 2021/04/14 to 2024/04/14

Researcher(s): Name: Mrs I Meda
E-mail address: 49851292@mylife.unisa.ac.za
Telephone: 0749673153

Supervisor(s): Name: Dr H Olivier
E-mail address: olivih@unisa.ac.za
Telephone: 012 429 6753

Title of research:

Exploring how digital game-based learning with reward systems promotes the development of academic self-efficacy in Grade 4 Natural Sciences and Technology learners.

Qualification: MEd Psychology of Education

Qualification: MEd Psychology of Education

Thank you for the application for research ethics clearance by the UNISA College of Education Ethics Review Committee for the above mentioned research. Ethics approval is granted for the period 2021/04/14 to 2024/04/14.

*The **medium risk** application was reviewed by the Ethics Review Committee on 2021/04/14 in compliance with the UNISA Policy on Research Ethics and the Standard Operating Procedure on Research Ethics Risk Assessment.*

The proposed research may now commence with the provisions that:

1. The researcher will ensure that the research project adheres to the relevant guidelines set out in the Unisa Covid-19 position statement on research ethics attached.
2. The researcher(s) will ensure that the research project adheres to the values and principles expressed in the UNISA Policy on Research Ethics.

University of South Africa
Preller Street, Muckleneuk Ridge, City of Tshwane
PO Box 392 UNISA 0003 South Africa
Telephone: +27 12 429 3111 Facsimile: +27 12 429 4150
www.unisa.ac.za

Appendix B. GDE research approval letter

GAUTENG PROVINCE
Department: Education
REPUBLIC OF SOUTH AFRICA

8/4/4/1/2

GDE RESEARCH APPROVAL LETTER

Date:	**12 May 2021**
Validity of Research Approval:	**08 February 2021– 30 September 2021** **2021/128**
Name of Researcher:	**Meda I**
Address of Researcher:	**12 Swallow Crescent**
	Baker ton
	Springs
Telephone Number:	**0749673153**
Email address:	**irinemeda77@gmail.com**
Research Topic:	**Exploring how digital game-based learning with reward systems promotes the development of academic self-efficacy in Grade 4 Natural Sciences and Technology learners.**

Type of qualification	**Master's Degree**
Number and type of schools:	**1 Primary School**
District/s/HO	**Johannesburg East**

Re: Approval in Respect of Request to Conduct Research

This letter serves to indicate that approval is hereby granted to the above-mentioned researcher to proceed with research in respect of the study indicated above. The onus rests with the researcher to negotiate appropriate and relevant time schedules with the school/s and/or offices involved to conduct the research. A separate copy of this letter must be presented to both the School (both Principal and SGB) and the District/Head Office Senior Manager confirming that permission has been granted for the research to be conducted.

12/05/2021

The following conditions apply to GDE research. The researcher may proceed with the above study subject to the conditions listed below being met. Approval may be withdrawn should any of the conditions listed below be flouted:

Appendix C: Editing certificate

ShaSha Research
Quality - Inspired - World class

CERTIFICATE OF ENGLISH EDITING

This certificate confirms that the document listed below was proofread and edited by professionals at ShaSha Research. Grammatical, spelling, punctuation, syntactic and formatting errors were addressed during the procedure.

Title of Document:

EXPLORING HOW DIGITAL GAME-BASED LEARNING WITH REWARD SYSTEMS PROMOTES THE DEVELOPMENT OF ACADEMIC SELF-EFFICACY IN GRADE 4 NATURAL SCIENCES AND TECHNOLOGY LEARNERS

Author:

IRINE MEDA

Date of issue:

5 January 2022

Certificate number:

20220105/1

ShaSha Research
is a vibrant, cutting-edge and groundbreaking research consultancy of top global academics, leading scientists and accredited researchers. We provide support in the whole research ecosystem including writing, editing, proofreading, referencing, plagiarism checking, data collection, data analysis, transcribing, research article publication, supervision support and training, workshop facilitation, writing retreats, research clinics and conference planning.

ShaSha Research Solutions
info@shasharesearch.co.za
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6 Korea Rd, Westdene
Johannesburg, South Africa

Appendix D: SGB permission letter

The School governing body

Request for permission to conduct research at Glenhazel Primary School.

Title: Exploring how digital game-based learning with reward systems promotes the development of academic self-efficacy in Grade 4 Natural Sciences and Technology learners.

Dear sir/Madam

I, Mrs. Irine Meda am doing research under supervision of Dr. H. Olivier, a senior Lecturer in the department of Psychology towards a Med at the University of South Africa. We are inviting your school to participate in a study entitled: Exploring how digital game-based learning with reward systems promotes the development of academic self-efficacy in Grade 4 Natural Sciences and Technology learners.

The aim of the study is to explore how DGBL with reward systems promotes the development of academic self-efficacy in Grade 4 Natural Sciences and Technology learners. Your school has been selected because of its proximity to the researcher and availability of a computer lab.

The study will entail conducting 10 Digital game-based learning sessions with 10 Grade 4 learner participants during the 2nd and 3rd Term of 2021. Observations of the participants and semi-structured interviews will be conducted with the 10 learner participants. Lastly, summative assessment as well as the distribution and collection of questionnaires for 10 learner participants will be conducted.

The benefits of this study are delineated as follows:
• The study can add to knowledge – Since, no studies have been generated on this section of the population at your school, this study will add to knowledge. Furthermore, future Grade 4 learners and beyond will benefit from the study as they will gain some insight into some of the processes which might help them understand difficult scientific concepts.

• Game-based techniques acquired during the study might help develop their 21st century skills like problem solving and creativity.

• The data generated from this study has the potential to improve existing practices and policies regarding the adoption of digital game-based learning. Digital game-based learning might be

implemented in most schools as well as motivate schools to make use of technology especially within the COVID pandemic.

Potential risks are negligible and will not amount to more than the inconvenience involved in the time taken for the interviews (approximately 15-20 minutes) and the sharing and distribution of the questionnaires. These interviews will be arranged to work within their most convenient times. There are no foreseeable risks of harm or side-effects to either the participants or the institution. Pseudonyms will be adopted for the protection of the school. Learner participation in this study is voluntary. This means that they may decline to participate or to withdraw from participation at any time. Covid regulations will be adhered to i.e. wearing masks, sanitizing, and observing social distancing.

There will be no reimbursement or any incentives for participation in the research. Feedback procedure will entail a copy of the formal findings of the research project being made available to the department, school, and participants upon request. This will be in the form of hard copies and electronic versions.

Should you have a query regarding the study or related matters do not hesitate to contact me or my supervisor whose contact details appear below. I am prepared to complete any further documentation you might have for this study.

Thank you for taking the time to read this information and I look forward to further communication.

Yours sincerely

Irine Meda

074 967 3153

Irinemeda77@gmail.com

Supervisor: Dr. H. Olivier

0827275622

UNISA

Department of Psychology

Appendix E: Principal permission letter

The Principal

Request for permission to conduct research at Glenhazel Primary School.

Title: Exploring how digital game-based learning with reward systems promotes the development of academic self-efficacy in Grade 4 Natural Sciences and Technology learners.

Dear sir/Madam

I, Mrs. Irine Meda am doing research under supervision of Dr. H. Olivier, a senior Lecturer in the department of Psychology towards a Med at the University of South Africa. We are inviting your school to participate in a study entitled: Exploring how digital game-based learning with reward systems promotes the development of academic self-efficacy in Grade 4 Natural Sciences and Technology learners.

The aim of the study is to explore how DGBL with reward systems promotes the development of academic self-efficacy in Grade 4 Natural Sciences and Technology learners. Your school has been selected because of its proximity to the researcher and availability of a computer lab.

The study will entail conducting 10 Digital game-based learning sessions with 10 Grade 4 learner participants during the 2nd and 3rd Term of 2021. Observations of the participants and semi-structured interviews will be conducted with the 10 learner participants. Lastly, summative assessment as well as the distribution and collection of questionnaires for 10 learner participants will be conducted.

The benefits of this study are delineated as follows:
• The study can add to knowledge – Since, no studies have been generated on this section of the population at your school, this study will add to knowledge. Furthermore, future Grade 4 learners and beyond will benefit from the study as they will gain some insight into some of the processes which might help them understand difficult scientific concepts.

• Game-based techniques acquired during the study might help develop their 21st century skills like problem solving and creativity.

• The data generated from this study has the potential to improve existing practices and policies regarding the adoption of digital game-based learning. Digital game-based learning might be implemented in most schools as well as motivate schools to make use of technology especially within the COVID pandemic.

Potential risks are negligible and will not amount to more than the inconvenience involved in the time taken for the interviews (approximately 15-20 minutes) and the sharing and distribution of the questionnaires. These interviews will be arranged to work within their most convenient times. There are no foreseeable risks of harm or side-effects to either the participants or the institution. Pseudonyms will be adopted for the protection of the school. Learner participation in this study is voluntary. This means that they may decline to participate or to withdraw from participation at any time. Covid regulations will be adhered to i.e. wearing masks, sanitizing, and observing social distancing.

There will be no reimbursement or any incentives for participation in the research. Feedback procedure will entail a copy of the formal findings of the research project being made available to the department, school, and participants upon request. This will be in the form of hard copies and electronic versions.

Should you have a query regarding the study or related matters do not hesitate to contact me or my supervisor whose contact details appear below. I am prepared to complete any further documentation you might have for this study.

Thank you for taking the time to read this information and I look forward to further communication.

Yours sincerely

Irine Meda

074 967 3153

Irinemeda77@gmail.com

Supervisor: Dr. H. Olivier

0827275622

UNISA

Department of Psychology

Appendix F: Parental consent letter

Dear Parent

Your child is invited to participate in a study entitled: Exploring how digital game-based learning with reward systems promotes the development of academic self-efficacy in Grade 4 Natural Sciences and Technology learners.

I am undertaking this study as part of my master's research at the university of South Africa. The purpose of this study is to explore the development of academic self-efficacy in Grade 4 learners through the use of digital game-based learning and the possible benefits of the study are the improvement of existing practices and policies regarding the adoption of digital game-based learning. I am asking permission to include your child in this study because they will be able to provide the information that is needed in the study. I expect to have 9 other children participating in the study.

If you allow your child to participate, I shall request him/her:

- **Take part in an interview**

The interviews will be conducted in the backroom office of the computer lab where there will be no interruption. The 10 interviews, lasting approximately 15 to 20 minutes each, will be audio-recorded with the participants' and their parents' or legal caretakers' informed assent or consent for accuracy of transcription afterwards. Pseudonyms will be adopted for the protection of the participants.

- **Complete a questionnaire**

The learners will be required to complete a questionnaire. They will complete the questionnaire in the computer room. Pseudonyms will be adopted for the protection of the participants. The questionnaire will be completed at the beginning of the study and after the study.

- **Complete a test**

The learners will be required to write a summative assessment prior to the implementation and after the implementation of the DGBL. The summative assessment will be used to evaluate

learners' progress and compares learners' knowledge against specified standards at the end of DGBL.

・Complete a participant DGBL Journal

The Participant DGBL journal will consist of predesigned sheets that the learner participants complete after each DGBL session. The sheets of each learner will be placed in a file, named as the Participant DGBL journal. The predesigned sheets will be handed out at the beginning of each session as the second page had a score sheet that the participant learners have to fill during playing the games.

・Participant observation

Participant observation during the DGBL will be impromptu, that is, without an observation schedule. The impromptu observation of the participants during the DGBL will be captured in the research diary directly after each session. The date of each session will be indicated in the research diary.

Any information that is obtained in connection with the study and can be identified with your child will remain confidential and will only be disclosed with your permission. His/her responses will not be linked to his/ her name or the school's name in any written or verbal report on this study. Such report will be used for research purposes only.

There are no foreseeable risks to your child by participating in the study. Your child will not receive any direct benefit from participating in the study. However, the possible benefits are that the study can add to or improve their knowledge, game-based techniques acquired during the study might help develop their 21st century skills like problem solving and the study will be used for mapping responsive interventions. Neither your child nor you will receive any type of payment for participating in this study.

Your child's participation in this study is voluntary. This means that may decline to participate or to withdraw from participation at any time. Withdrawal or refusal to participate will not affect him /her in any way. Similarly, you can agree to allow your child to be in the study now and change your mind later without any penalty.

The study will take place after regular classroom activities with the prior approval of the school and your child's teacher. The information gathered from the study and your child's participation in the study will be stored securely on a password locked computer in my locked office for 5 years after the study. Thereafter, the records will be erased.

Should you have a query regarding the study or related matters do not hesitate to contact

me or my supervisor whose contact details appear below.

Thank you for taking the time to read this information and I look forward to further

communication.

Yours sincerely

Irine Meda

074 967 3153

Irinemeda77@gmail.com

Supervisor: Dr. H. Olivier

UNISA

College of Education

Department of Education

Appendix G: participant assent

UNISA university of south africa

ASSENT TO PARTICIPATE IN THIS STUDY (Return slip)

I, _____ (learner participant name), understand that my parents/guardian have given permission for me to participate in a study at my school. My involvement in this project is voluntary, and I have been told that I may withdraw from participation in this study at any time without penalty and loss of benefit to myself. I confirm that the person asking my assent to take part in this research has told me about the nature, procedure, potential benefits and inconvenience of participation.
I am willing to be in the study.

_____	_____	_____
Learner's name (print):	Learner's signature:	Date:
_____	_____	_____
Witness's name (print):	Witness's signature	Date:

(The witness is over 18 years old and present when signed.)

Appendix H: Adapted Academic Self-Efficacy Scale (Muris 2001)

	1 Not at all	2 Seldom	3 Not so well	4 Well	5 Very well
1. How well can you get the Science teacher to help you when you get stuck on schoolwork?	1	2	3	4	5
2. How well can you study Science when there are other interesting things to do?	1	2	3	4	5
3. How well can you study Science for a test?	1	2	3	4	5
4. How well do you succeed in finishing all your Science home-work every day?	1	2	3	4	5
5. How well can you pay attention during every Science class?	1	2	3	4	5
6. How well do you succeed in understanding Science in school?	1	2	3	4	5
7. How well do you succeed in satisfying your parents with your schoolwork?	1	2	3	4	5
8. How well do you succeed in passing a Science test?	1	2	3	4	5

Categories of the Adapted Academic Self-Efficacy Scale (Muris 2001)

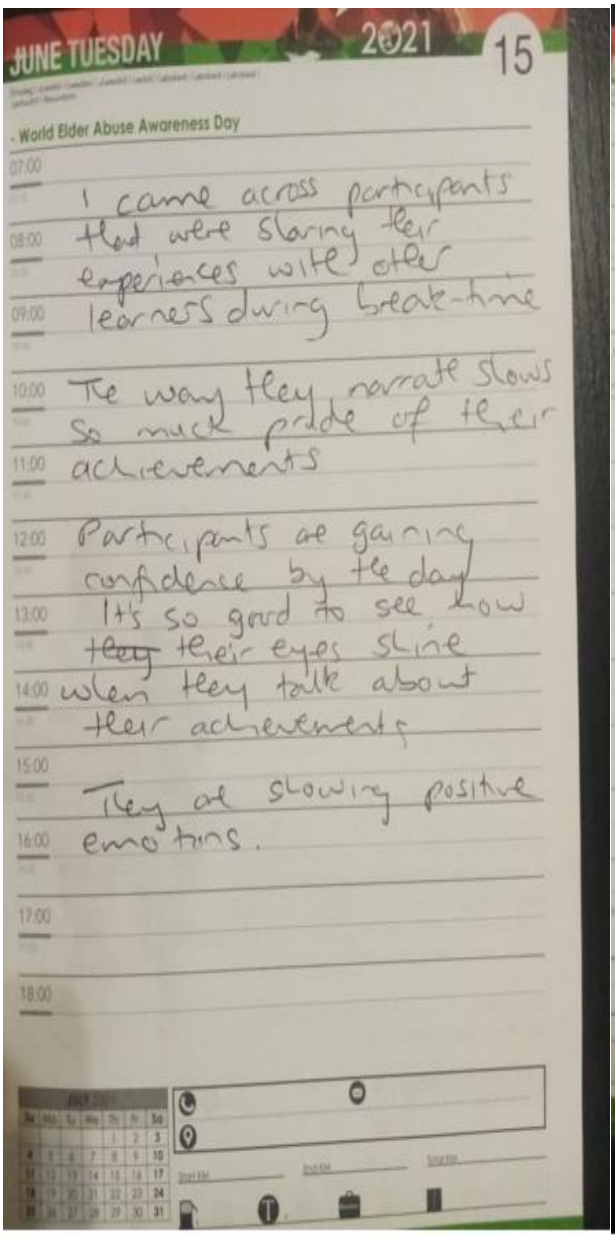
Score	Category
8	Low
16	Below average / lower average
24	Average
32	Above average / higher average
40	High

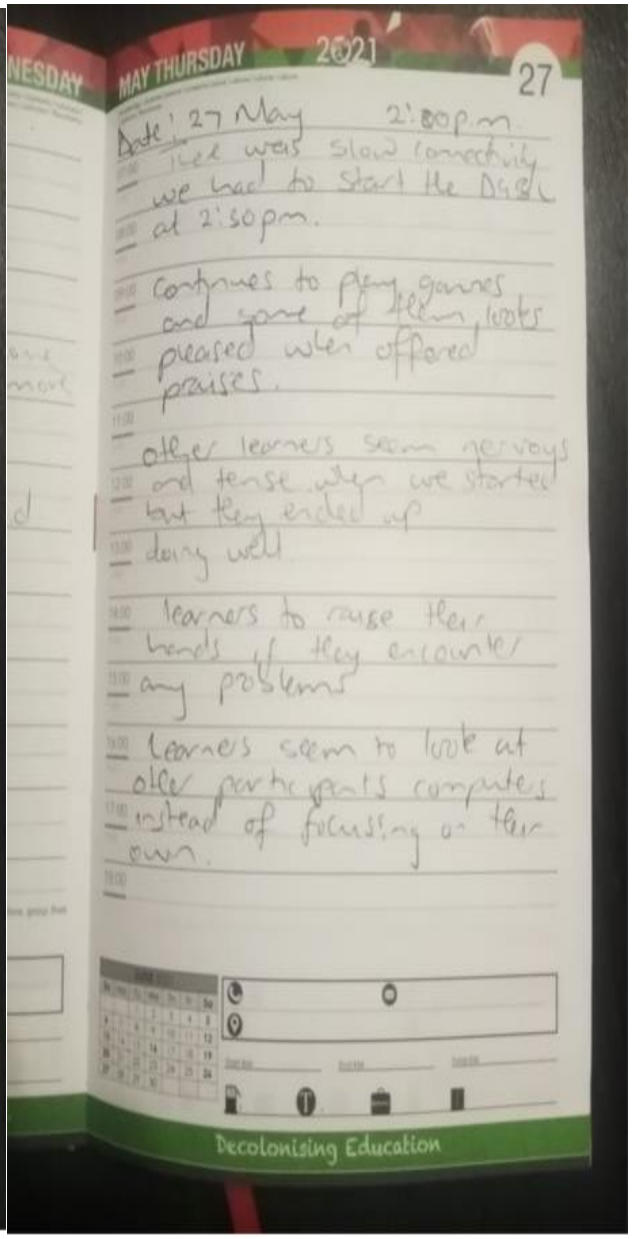
Appendix I: Observation schedule

Observations are ticked and overall impression added at the bottom			
Participant pseudonym (e.g. P1 or P2 up to P10)	_____	**Interview Date:** **Time:** **Duration:**	_____ _____ _____
Behaviour	**Tick**	**Comments**	
Open and relaxed			
Tensed / uneasy			
Responsive			
Unresponsive			
Strong convictions			
Uncertain			
Interested			
Bored			
Attentive			
Easily distracted			
Positive emotions			
Negative emotions			
Age appropriate behaviour			
Age inappropriate behaviour			
Other			

Overall impression and possible referral	

Appendix J: Research Diary template





Appendix K: Participant DGBL journal

DGBL Journal

Your name: _____ **Todays date:** _____

Name of the game: _____

1. Mark the block OR blocks that describe you best with an X.

After playing the game, I feel:

	**Uncertain** 	**Like a winner** 	**Frustrated** 	**Bored** 

2. Mark your experiences and thoughts during this class with a tick (√) – there are no right or wrong answers

I was confident (believed in myself) that I could master the game.	When my friends mastered the game, I decided that I can also do it.
I knew that I could not master the game.	The game helped me to understand Science better.
I feel proud of myself.	I did not give up until I mastered the game.
I would like to play more Science games.	I am in a good mood today and did well.
I would not like to play more Science games.	I am in a bad mood today and did not do well.
It helped me a lot when my teacher said that I was doing well.	

3. Write other remarks here:

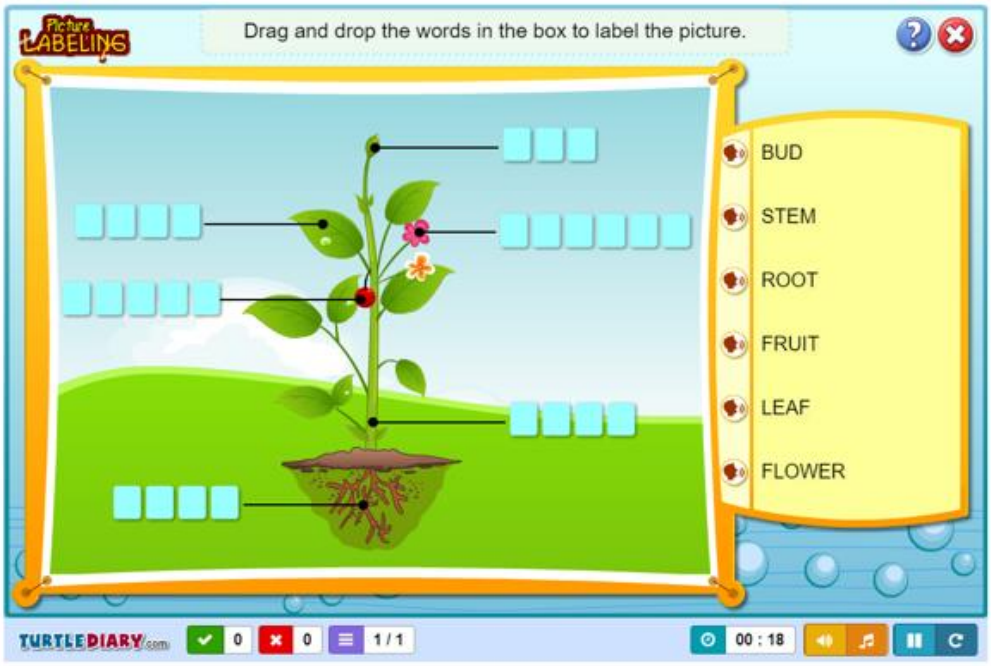
_____

_____

_____

_____

Score sheet – *Plant Parts Labeling*



Write down the number of the answers (√ and X)

Right answers	Wrong answers
1.	1.
2.	2.
3.	3.
4.	4.

Appendix L: Interview Schedule

Interview schedule

Name of interviewer: ----------

Name of interviewee: ----------

Place of interview: ----------

Date of interview: ----------

Sequence	Questions
Question 1	Describe your overall experience of the computer games in one word, if you can. You can also use more than one word, if need be.

Question 2	If you feel that the games helped you, tell me how the games helped you. If the games did not help you at all, we will skip the question.
Question 3	What did it mean to you when you mastered the game?
Question 4	Although the games were not a competition between your class friends, what did you say to yourself when you saw that *they* mastered the game?
Question 5	Can you remember a specific incident, or more than one, when you were encouraged or praised? Tell me about it. What did it mean to you?
Question 6	Would you mind telling me how your emotions, that is, how you feel, influenced your game playing? What did you think or say to yourself? [Examples in general can be given if the learner participant requires more information.]
Question 7	Think back of your Science achievements in Term 1. Are you happier now, after playing the games, with your Science achievements? If you say "yes", tell me about your achievements. (What can you manage now?)
Question 8	(if question 7 was answered positively) Science is a challenging subject and you have just told me about your achievements. How do you feel about your other subjects? Will you be able to improve your achievements in other subjects as well? I would like to hear your thoughts.
Question 9	After playing the games, do you now believe in yourself to be successful in Science? [If negative:] Tell me why you do not believe in yourself.
Question 10	If you had shared your game playing experience with your parents, what was his or her reaction?
Question 11	What could I have done differently during the game playing sessions to assist you?

Appendix M: DGBL Planning sessions

Planning of digital games in Term 2 & 3 in 2021

Play 7 games at least once over 10 sessions of 30 min each, every week

S	M	T	W	T	F	S	May
						1	
2	3	4	5	6	7	8	
9	10	11	12	13	14	15	
16	17	18	19	20	21	22	
23	24	25	26	27	28	29	
30	31						

Term	Session	Date
Term 2	1	13 May
	2	20 May
	3	27 May
	4	03 June
	5	10 June
Term 3	6	17 June
	7	24 June
	8	4 August
	9	11 August
	10	16 August

Term	Duration	Number of weeks	Number of days	Number of public holidays	Actual number of school days
1	(25 Jan) (01) 15 Feb – 23 Apr	(13) (12) 10	(65) (60) 50	3	(62) (57) 47
2	3 May – 9 Jul	10	50	1	49
3	26 Jul – 01 Oct	10	50	2	48

4	11 Oct – 15 (15) Dec	10	48 (48)	0	48 (48)
	Total	(43) (42) 40	(213) (208) 198	6	(207) (202) 192

Appendix N: Attendance Register

Digital Game-based learning Attendance Register

Date: ---------- **Month: ----------**							
Participant	**Week 1**	**Week 2**	**Week 3**	**Week 4**	**Week 5**	**Week 6**	**Week7**
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							