Cape Peninsula University of Technology

HOW ONLINE MATHEMATICS GAMES HELP GRADE 8 MATHEMATICS LEARNERS UNDERSTAND ALGEBRA

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ABSTRACT

Emergent technologies, such as online mathematics games, have rejuvenated learning mathematics and opened its boundaries to a much wider audience of learners. Integrating online mathematics games into teaching and learning has proved to be invaluable in many unexpected and exciting ways. The constructivist priorities underlying CAPS are complemented by the emphasis on independent learning facilitated by mathematics pastime. The research investigates the contribution of online mathematics games to understanding algebra in grade 8 Mathematics. This research tracks and documents the trajectory of a purposive sample of thirty grade 8 learners doing mathematics and one mathematics teacher. This research is premised on the argument that learners can better grasp algebraic concepts and learn to manipulate them imaginatively and independently by integrating new online mathematics games into standard classroom teaching of mathematics. The paradigm used in this research was an interpretive subjective contextual investigation approach (Ponelis, 2015). The research is based on the following primary question: Do online mathematics games contribute to Algebra understanding in Grade 8? and the following sub-questions (i) What understandings of Grade 8 Algebra improve through being exposed to online mathematics games? (ii) How does an online mathematics game contribute to Algebra understanding in Grade 8? Data were collected by (i) observing lessons, (ii) drawing up and administering questionnaires and (iii) conducting semi-structured interviews. Data were collected and scrutinized using socio-cultural theory, social constructivism and activity theory. Further research should be piloted on a huge scope with many schools in different areas and to revisit the curriculum to allow online mathematics games to be integrated into our classrooms at all levels and in all subjects.

DECLARATION

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

……. ……

Signed Date

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I thank The Almighty, The Omnipotent and Omniscient God who gave me life, wisdom and strength, without which this work would not have been possible.
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The principal, Mathematics H.O.D of the sample school, learners and teacher who participated in the research. These people made it possible for me to carry on my research.

DEDICATION

This thesis is dedicated to my wife, Evelyn; my son, Asher; daughter, Moreblessing.
Thank you for your continuous support during my studies.

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1.1. Introduction and background

This study assesses the value, feasibility and affordability of online mathematics games as a means of increasing, enhancing and expanding Algebraic concepts amongst the Grade 8 learners. The high failure rate of learners in Algebra points to a need for new, more attractive and engaging methods for teaching and stimulating the learning of Algebra. Learners who have difficulty grasping basic concepts in Mathematics often have poor prior knowledge. Learners who are introduced to online mathematics games can, however, regain lost ground, self-motivation and intense interest (McLaren, Mayer, Adams & Forlizzi, 2017:49). Online mathematics games stimulate learners so that they learn without realising it.

Algebra is one of the major topics in the South African Mathematics Syllabus. Algebraic thinking has ignited debate in academic circles (Drijvers, 2003:1), since this topic is considered one of the most difficult in the Mathematics curriculum and often becomes a stumbling block. When learners enter high school, they are introduced to an algebraic way of understanding concepts. Chick, Stacey, Vincent Ji and Vincent Jo (2001:1) say “as the language of higher Mathematics, algebra is a gateway to future study and mathematically significant ideas, but it is often a wall that blocks the path of many”. Learners are introduced to symbols representing unknowns and are required to use them in writing equations.

The compact algebraic language, with its detailed conventions and signs can be confusing. Algebraic formulae and expressions sometimes present problems through a ‘lack of closure’. Vermeulen (2007:14) lists the difficulties often experienced by learners in algebra. These problems are mostly the result of learners not having received correct tuition about the elementary ideas in algebra, namely variables, algebraic expressions and equations. Learners fundamentally make errors while implementing algebraic procedures. Learners often make mistakes while executing algebraic operations and they find it hard to trace their errors or improve their performance. The difficult aspects for learning algebra according to Drijvers (2003:41) are, “formal, algorithmic character of algebraic procedures that the learner

cannot relate to in any familiar, informal and meaningful approaches. The abstract level at which problems are solved compared to the concrete situations they arise from, and the lack of meaning that the teacher attributes to the mathematical objects at the abstract level can alienate learners". As (Drijvers, 2003:2) points out, this introduction to a formal algebraic system creates confusion for many learners who miss the basic first steps and are unable to catch up later. Jupri and Drijvers (2016:2) elaborate:

> Many learners have difficulty when they encounter algebraic problems in school. Lacking real understanding of the concepts involved and experience in finding solutions, they are confused about which procedure to apply or why is it relevant?

Online mathematics games introduce learners to such fundamental steps in an attractive and easy way so that many learners gain knowledge without consciously sensing that they are being taught. Many learners who would otherwise have given up or never have started mathematics, blossom. I want to assess how and why online mathematics games attract, educate, engage and stimulate learners to find out more about Algebra. Questions arise: Which games are most effective? What kind of learners respond to which games and why?

Little previous research has recognised, appreciated or investigated how exactly online mathematics games advance learner understanding of Algebra. According to Becker (2005:2) the potential value of online mathematics games for learning is high. But the body of in-class research on the use of online mathematics games is still small – partly because learning through online mathematics games in the classroom faces considerable resistance from conservative educators. Griffiths and Davies (2002:379) postulate that because online mathematics games are so fresh, little is acknowledged about the thinking of web-based gaming and its relation to learning quests.

Most teachers seek proof of the effectiveness of online mathematics games as effective learning tools, before adopting them in the classroom. One way to help convince more teachers is to try online mathematics games through pedagogy: by connecting elements of existing game designs with accepted learning and

instructional theories (Becker, 2005:2). Kebritchi, Hirumi and Bai (2010:427) aver that, “there is a dearth of empirical research about the precise effects of online Mathematics games on learning in formal school settings to guide future research and practice”.

As the result of a complex of factors, historical, socio-economic and political, post-liberation South Africa presently is embroiled in a predicament in mathematics education; especially in algebra which has resulted in the country being positioned last in the Third International Mathematics and Science Study (Smith & Hardman, 2014:22)**.** Online mathematics games may indeed be able to break the deadlock in mathematics education nationally. Such a breakthrough would increase the chances of learning and enjoying mathematics for all, poor and wealthy, black and white, quintile 1 to 5. Using online mathematics games in schools could help ease a worsening situation in an affordable, democratic and relatively timely manner, permitting changes in pedagogical practices and potentially profiting learners.

A lot has been said concerning the potential of online mathematics games to go about as a stimulus in transforming academic practices in classrooms. According to Smith and Hardman (2014:23) “There is a relative dearth of research regarding how exactly online mathematics games could transform pedagogy, especially in developing countries where access to this technology has only recently become available to learners who are, in many cases, educationally and economically disadvantaged”.

According to Kebritchi et al. (2010:428) a brief evaluation, using Cooper`s 1985 framework, indicates that of the 40 studied online Mathematics games, just 16 experimental examinations and 4 writing audits concentrated on the benefits of online Mathematics games in supporting education in an official school background. Most previous research studies have been limited to Algebraic errors and computational fluency. According to Afari, Aldrie, and Fraser (2012:138), the results of their studies suggest that online mathematics games in Mathematics can improve a learner`s understanding of concepts. But this finding has not been systematically verified. The contradicting views of the literature analysis and the presence of comparatively limited experiential studies in school situations necessitated further

rigorous empirical study to assist educators enhance comprehension, apply and facilitate online Mathematics games in classroom (Kebritchi et al., 2010:428). This research seeks to unearth evidence to verify the position that online mathematics games may improve a learner`s understanding of Mathematics concepts. I need to determine which games are most effective and why. I hope that the findings of this dissertation may be helpful to novice and expert teachers alike, in improving the initial teaching of algebra.

1.2 Statement of research problem

Government has encouraged use of Online Mathematics games as a vehicle of guidance in the mathematics classroom (DBE, 2009:3). Yet, teachers plus learners seem to continue to use, or revert to, old traditional methods. After 10 long years of instructing as a Senior Stage educator at a school in the Western Cape, I became mindful that learners were encountering difficulties with arithmetic, especially Algebra. In the Senior Phase, the most well-known issue was that learners did not appear to have a confident and real apprehension of Algebra. They were not able to own algebra, manipulate its resources and explore its wide potential in any imaginative way. It appeared that learners had been trained and educated by rote. The problem with rote learning in mathematics pedagogy in particular is that it does not necessarily stimulate engagement and exploration, but in fact closes down such self-discovery. Lithner (2017:937) aver that rote learning depend on method and retention, which make it hard for a lot of learners to apply understanding. Innovative and effective techniques of teaching Mathematics are consequently required to overcome this counterproductive pedagogy. Use of online mathematics games could break this reversion to apartheid pedagogy.

Online Mathematics games are exciting tools for teaching and learning of algebra since they permit learners to study independently; for example, Online Mathematics games are used in deducing difficult ideas in diverse topics. Online Mathematics games assist learners acquire knowledge by improving their learning surroundings, resources and independence. There are many challenges that hinder the process of using Online Mathematics games in the classroom. Nonetheless, once successfully used, online mathematics games can have an intense result on classroom

atmosphere, as concluded by Reid and Rushton (1985). But, if not applied efficiently, no value is added to learning.

A confident teacher mentality encourages the utilization of online mathematics games, while a bad one delays their use in the classroom. This research aims to address the following main question:

How do online mathematics games contribute to Algebra understanding in Grade 8?

The researcher therefore sought to determine the advantages of using online mathematics games in learning Algebra and whether Online Mathematics games contribute to Grade 8 learners` understanding of Algebra.

1.3. Significance of the research

Various research studies (Chick et al, 2001; Jupri and Drijvers, 2016; Drijvers, 2003; Barkatsas, Kasimatis and Gialamas, 2009; Van Ameron, 2003; Rosnick, 1981; BECTA, 2001; Bokhove and Drijvers, 2012) have been conducted on online mathematics games in the learning of algebra. I have not, however, discovered any research related to the contribution of online mathematics games on Grade 8 algebra. The significance of the research relates to the analysis of the contribution of online mathematics games in the learning of algebra in Grade 8 and how it might improve learner understanding of algebraic concepts. This research aims to investigate different ways in which online mathematics games can be used as a valuable, reliable and affordable tool for improving Grade 8 algebra understanding. The study may assist a number of stakeholders including policy makers and teachers in implementing strategies to improve performance and understanding of algebra. In addition, the findings may be used by the Department of Education to develop more online mathematics games which can be used by mathematics teachers.

1.4. Purpose of study

The objective of the investigation is to clarify and increase comprehension into the question of whether online Mathematics games contribute to Algebra understanding in Grade 8 Mathematics. I intend to build up evidence by means of intensive

production of narrative data. This research aims to develop and enhance strategies to rectify problems that Grade 8 Mathematics learners often encounter in Algebra. I believe that learners may understand algebraic concepts better in Further Education and Training (FET) if a sound foundation is positioned in the senior level. If learners graduate from the senior phase with a solid mastery of algebraic ideas, then they will know how to apply it in solving algebraic expressions and equations. Their knowledge will be more secure, entrenched and provide a better platform for more advanced exploration of a vital field for South Africa which is poised and expected nationally, to be preparing learners for the fifth industrial revolution.

1.5. Research Questions

This research is premised on the accompanying principal question:
How do online mathematics games contribute to Algebra understanding in Grade 8?

In light of the issue identified and the hypothetical system, the research looks to respond to the accompanying sub-questions:

(i) What understandings of Grade 8 Algebra improve through being exposed to online mathematics games?
(ii) How does an online mathematics game contribute to Algebra understanding in Grade 8?

1.6. Research aims

Beneath is the key objective that this investigation wanted to attain:

To examine the contribution of online mathematics games in Algebra understanding in Grade 8.

Taking into consideration the research key goal of the examination above, the investigation purposes:

(i) To establish which understanding of Grade 8 Algebra improves through being exposed to online mathematics games.
(ii) To find out if online mathematics games contribute to Algebra understanding in Grade 8.

1.7. Research strategy

A qualitative approach was adopted, using an interpretive paradigm and using a school in the Northern Metro district of Cape Town in the Western Cape Province as a contextual analysis. The case study method, as indicated by de Vaus (2001:220) is pluralistic, descriptive and heuristic, indicating that the case study is focused on a specific event and has the potential to provide meaningful insight into how individuals confront problems through a holistic view of the situation.

Using a contextual analysis was necessary due to the point that there are a lot of schools in the Western region. Examining all the schools requires considerable time and assets which were most certainly not accessible for the researcher. Studying the contribution of online mathematics games inside one locale made a difference in providing awareness into its value in Algebra lessons. Recommendations could be made for integrating online mathematics games into Algebra lessons, using the discoveries of this examination. This investigation was piloted in one school in Western Cape region; therefore, its discoveries may not be summed up to all regions, however, might be utilized as a foundation when researching on a wider scale.

1.8. Research population

As indicated by Strydom and Venter (2002: 199) “In research, the population refers to the totality of persons, events, organization units and cases with which the specific research problem is concerned”. The preliminary target population for this research comprised of grade 8 learners in northern Metro area of Cape Town in the Western Cape Province. A sample of 31 participants was projected, drawn from the target population mentioned above.

1.9. Sampling techniques

`De Vos, (1998:190) characterizes a sample as a “portion of the elements in a study population that is studied in an effort to understand the population from which it was taken”. The researcher employed convenience sampling to designate participants to base the study. Wegner (2007:214) states that convenience sampling is ideal since

sampling units are selected to suit the convenience of the researcher. Therefore, Grade 8 Mathematics learners were targeted.

1.10. Sample size

The anticipated sample comprised of a total of **31** members as depicted underneath:

(i) Grade 8 Mathematics learners N = 30

(ii) Grade 8 Mathematics teachers N = 1 (Total Sample size: N = 31)

1.11. Limitation of the study

Participants were not randomly selected but convenience sampling method was used. However, participants were selected because of their accessibility to the researcher. The sample of the research was too small, and the time spent to conduct the study was very short. Only one high school in Goodwood in the Western Cape Province was the research going to be conducted. It was also limited to learners in Grade 8 and a few Grade 8 Mathematics teachers. The limited resources and time forced the researcher to conduct the study in one district only. Only one topic, algebra, was the focus. The results of this study reflect only what happened with this particular group of learners. Hence the need not to generalize the findings of the research but rather used as a foundation for broader study in future.

Learners who were included in the sample were agreeable to participate in the study. The main instrument used was a self-reporting questionnaire that was triangulated with semi- structured interviews and classroom observations. Many challenges emerged during the initial stages of persuading the participants to participate in this study. These difficulties shaped my approach, because I initially had to draw on personal negotiation strategies to gain 'access'.

Selecting a case study approach has limitations that pertain to lack of generalizability. This limitation must be acknowledged. Although advocating for a no less than "rigorous methodological path" (Yin, 2009:15), case study methodology has its strengths and weaknesses, which are outlined in Chapter 4. A further limitation was related to time constraints. As an in-service teacher, I followed and committed myself to a fixed teaching schedule, which did not allow for much

flexibility: it was not always possible to align my schedule with an observation session with one of the participants. Participant observation requires understanding of the environment on the part of the researcher. My workload first as a teacher and then as a researcher, the school programme, the term holidays and other scheduled term breaks, all presented possible 'stumbling blocks'. In addition, sensitive navigation was needed to comply with ethical considerations. I was fully cognisant of the fact that as a colleague and teacher of the research participants and an employee at the research site, researcher bias could compromise the investigation.

1.12. Delimitations of the research

The scope of this research was limited to one school, which was privileged in terms of its resource provisions. Only one school in the Metro North district was used in this study. Only Grade 8 learners and teachers were included in the sample because I had easier access to these classes and could schedule research in terms of my workload. The different timetables of the two Phases prevented a possible alignment with the time available for conducting observations. It is possible that the inclusion of Senior Phase teachers might have provided a different perspective to the study.

1.13. Importance of study

The research showed that online mathematics games can improve learners' comprehension of algebra, then it is possible that online mathematics games may be incorporated into standard instruction to improve learners' understanding in Mathematics.

1.14. Structure of thesis

The dissertation consists of five chapters. The following shows how every chapter is summarized:

1.14.1. Chapter One

This section consists of preamble, background, purpose and objectives, research questions, limitation, and summaries of all chapters. The chapter provides a summary of what will be discussed in the other chapters of the research.

1.14.2. Chapter Two

The section provides discussion of, and background to, the theories related to the contribution of online mathematics games in teaching Grade 8 algebra. The literature review and the theoretical framework are discussed in more detail concerning the contribution of online mathematics games in teaching algebra.

1.14.3. Chapter Three

This section describes the research paradigm, design and methodology used. A comprehensive discussion is provided of data collection techniques, the roles of the researcher and the sampling methods. Finally, the chapter discusses the ethical issues considered in conducting the research.

1.14.4. Chapter Four

Chapter four discusses findings and data analysis of the research from the data collected. The results of the data collected are presented and discussed in depth. The views of participants are outlined and analyzed to discern patterns and meaning from the collected data.

1.14.5. Chapter Five

This chapter deals with the conclusion and recommendations from findings of the research. The chapter discusses the conclusion and recommendations.

1.15. Conclusion

Chapter 1 discussed the research background, the purpose of the research, the research question, limitations of the study, a summary of the structure of the thesis and the research methodology. It provided some outlines of all the chapters of the thesis.

The next chapter discusses the theoretical framework underpinning the study and presents the literature review about online mathematics games in the mathematics classroom. In addition, I will look at reasons for using online mathematics games when conducting algebraic lessons.

CHAPTER 2: Literature Review and Theoretical Framework

2.1. Introduction

There is considerable evidence in the relevant literature about the advantages of online mathematics games for teaching Mathematics (Chick et al., 2001; Jupri & Drijvers, 2016; Drijvers, 2003; Barkatsas, Kasimatis & Gialamas, 2009; Van Ameron, 2003; Rosnick, 1981; BECTA, 2001; Bokhove & Drijvers, 2010). Technologically, the world has become a global village that is interconnected and highly competitive. Teachers are becoming more aware of the value of online mathematics games for teaching high school Mathematics. Most teachers now appreciate the significance of utilizing online mathematics games when teaching Mathematics (Jupri & Drijvers, 2016; Van Ameron, 2003).

Drijvers (2003:3) holds the view that the term 'Algebra' is often intimidating for many high school learners but that it does not have to stay that way. There is no substitute for practice to get better at Algebra, and online Mathematics games may be a simple way for learners to exercise their Algebra skills. Fun, fast-paced, online Mathematics games are exciting for high school learners, and can aid in understanding Algebra through unique representations of algebraic concepts. Learners live in a world of electronic communication: they can sometimes gain more information, more quickly by learning with online mathematics games than by sitting and listening to a teacher talk. Online mathematics games mark a pedagogic shift from traditional methods of transmitting information, towards dynamic and concerted learning through learners` engagement (Department of Education, 2003:9).

Online mathematics games could be useful for a number of reasons, if we take the cognitive approach to learning into account (Williams & Huang, 2015:498). Scholars such as Paraskeva, Mysirlaki and Papagianni (2010) and Williams and Huang (2015) claim that the probability of skills learned and practised using online mathematics games are more likely to be transferred as compared to those practised on a single problem. Once grasped, the skills are practised to promote over learning. According to Rohrer and Taylor (2006:1209) "overlearning is the recurrent exercise of a skill or learning of materials to reinforce retention and presentation. Overlearning leads to

the skills becoming automatized and merged in memory, so that the learner can start to focus consciously on applying new information".

2.2. Teaching and learning of mathematics?

Before delving into the literature on online mathematics games and algebra, I need to have a full understanding of what mathematics is and why people teach it. There is no consensus on the definition of mathematics because of its vast scope. The saying is that mathematics is what Mathematicians do. Although no clear definition exists, Van de Walle, Karp and Bay-Williams (2013:257) posit the following meanings of mathematics:

> Mathematics is seen as a language, an art, a science, a tool and a game. Mathematics is the language used to express size and order; Mathematics is the study of measurement, properties and relations between quantities and sets, using numbers and symbols; Mathematics can be viewed as the systematic study of magnitude, quantities and relation as expressed symbolically in the form of numerals and forms; as a tool, Mathematics aids in representing and attempting to resolve problems and situations in all disciplines such as science, business and industry; Mathematics is an interdisciplinary tool and language: it describes, explains as well as predicts what might happen in our everyday lives and as a science, Mathematics deals with the logic of shape, quantity and arrangement.

Mathematics is a science of pattern and order which means that mathematics solves a variety of practical tasks and real-life problems (Van De Walle et al., 2013:257). Mathematics is a science that traces patterns of regularity and logical order. This statement implies that mathematics is about finding and exploring regularities and order as well as making sense of it. According to Siemon et al. (2016:6) Mathematics may be seen as a product of insightful human activity and socio-cultural practice. The fact that mathematics can be viewed as a socio-cultural practice leads the researcher to adopt socio-cultural theory for this project.

By taking a closer look at the above meanings, one can deduce that mathematics is a way of organising our experience of the world. The view that mathematics is a

science of pattern and order can influence teacher`s belief concerning how to teach mathematics. Cross connections between mathematical concepts such as symbolic representation of Algebra and spatial representation of geometry, widen a teacher`s insight, increasing an appreciation of the correctness and fundamental unity of mathematics.

2.2.1. Goals of Mathematics

Taking a closer look at the National Curriculum Statement (CAPS, 2011:13) “the teaching and learning of Mathematics aims to develop a critical awareness of how mathematical relations are used in social, environmental, cultural and economic relations. Mathematics builds confidence and competence to deal with any mathematical situation without being hindered by a fear of Mathematics; a spirit of curiosity and love of Mathematics; an appreciation for the beauty and elegance of Mathematics and recognition that Mathematics is a creative part of human activity which needs deep conceptual understanding in order to make sense of the discipline”.

Mathematics educators teach school mathematics because they want to instil certain decisive skills which support learners to adopt meaningful roles in the society as a whole. Mathematics skilled citizens are needed to transform South Africa and make it ready for the fifth industrial revolution. Mathematics equips learners with skills that help them solve problems, understand phenomena in the physical world as well as equip them with skills to process information obtained from physical, social and cultural situations. Mathematics Educators teach mathematics to train learners to think logically. Those who can understand mathematics have great opportunities for shaping their prospects and accessing fruitful careers. Failure to understand mathematics concepts can keep those doors shut.

It is significant that learners attain mathematical mastery by building their own connotations through stages of abstraction. This is done through evaluating their individual capabilities. The following diagram shows a vivid description on how learners can do mathematics.

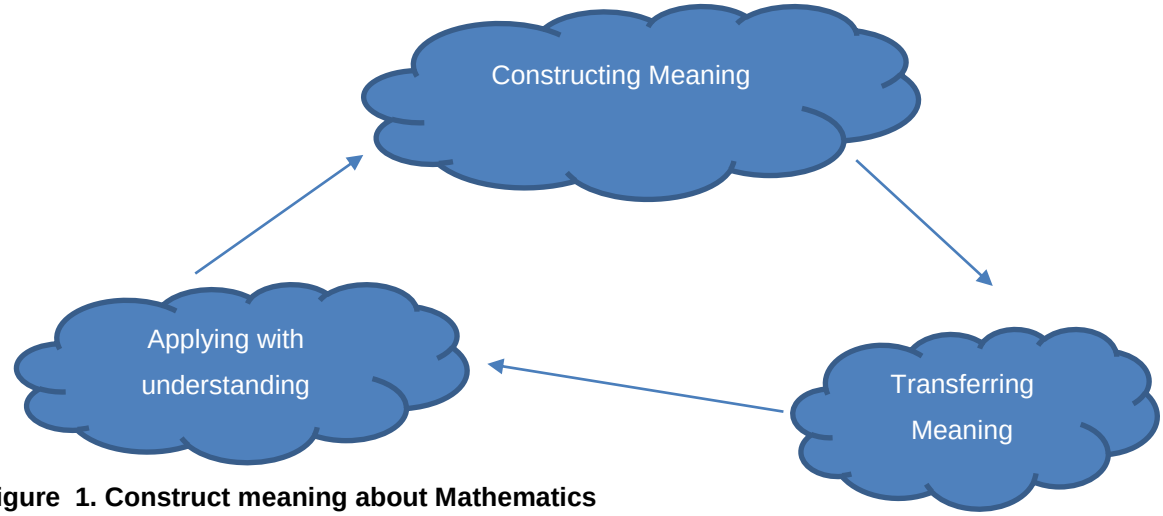


Figure 1. Construct meaning about Mathematics

(Source: Papandayan, 2009)

Learners use prior experiences and understanding as well as considering their interactions with objects and ideas to develop meaning and understanding. Learners are exposed to opportunities which allow them to manipulate symbols and to converse with one another. “For learners to be able to use and apply the Mathematics they learn at school, they need to experience it as a meaningful, interesting and worthwhile activity. Online mathematics games are the best medium to achieve it (DBE, 2009:3)”.

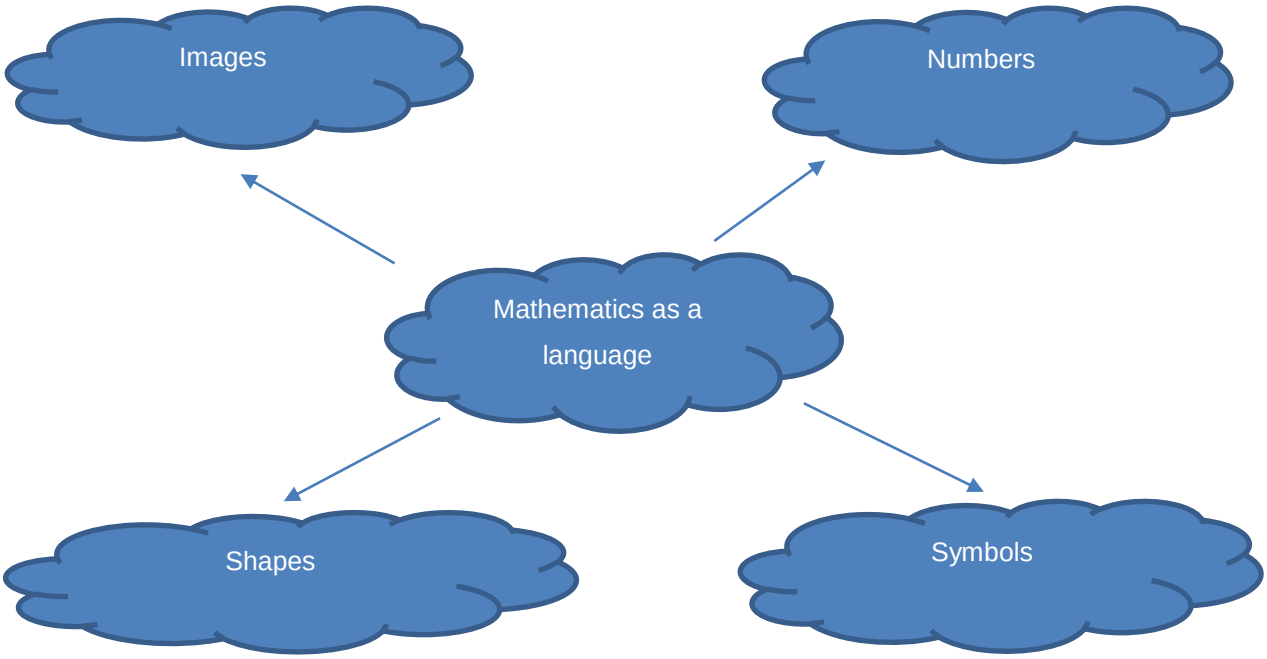


Figure 2. Mathematics as a language

(Source: Papandayan, 2009)

Mathematics utilizes numbers, images, shapes and pictures to impart our consideration. To be effectively associated with our networks we have to comprehend what numbers and images, shapes and pictures let us know.

2.2.2. The five strands of Mathematics proficiency

Concepts and connections develop over time thus tasks must be strategically selected to help learners build connections hence the use of online mathematics games (Bottino, Ferlino, Ott & Tavella, 2007:1274). The more robust their understanding of a concept the more connections learners are building and the more likely it is for them to connect new ideas to the existing conceptual webs they have.

In this regard, the five strands of mathematics are discussed so as to clearly show what should be done for learners to conceptualise mathematical concepts. The five strands of mathematical proficiency are: conceptual understanding, procedural fluency, strategic competence, adaptive reasoning and productive disposition (Chang, Evans, Kim, Norton & Samur, 2015:48). These strands become ever interwoven and interdependent as proficiency in mathematics is developed.

(i) According to the NRC (2001:118) “conceptual understanding refers to the integrated and functional grasp of mathematics ideas, which enable learners to learn new ideas by connecting those ideas to what they already know. Conceptual understanding involves comprehension of mathematical concepts, operations and relations”.

(ii) “The second strand is procedural fluency which is defined as the skill to carry out procedures flexibly, accurately, efficiently and appropriately” (Groth, 2017:104).

(iii) “The third strand is strategic competence which is the ability to formulate, represent and solve mathematical problems” (Groth, 2017:104).

(iv) “The fourth strand is adaptive reasoning. Adaptive reasoning is the capacity for logical thought, reflection, explanation and justification” (Groth, 2017:104).

(v) “The last strand is productive disposition, which is the inclination to see mathematics as sensible, useful and worthwhile, coupled with a belief in diligence and one`s own efficacy” (Groth, 2017:104).

2.2.3. Benefits of developing mathematical proficiency

Russel (2000:155) mentions the benefits connected with developing mathematical proficiency. These benefits are:

> When ideas are well understood and make sense, the learner tends to develop a positive self-image and confidence in his/her ability to learn and understand mathematics. Learner confidence, competence and interest in mathematics flourish when new experiences are meaningful and connected with prior knowledge and experience.

Learning mathematics improves attitudes and beliefs amongst learners (NRC, 2002:11).

According to Bottino et al. (2007:1276) the other benefit is that mathematics enhances retention and recall. Recovery of facts is more likely to happen when concepts are linked with the full net of notions. NRC (2001:120) goes on to claim that when concepts are rooted in a rich web, transferability and problem solving is immensely improved.

Groth (2017:106) holds the view that building mathematical proficiency increases effective learning of new ideas and expands educational and life opportunities. The more active the learner`s understanding of a concept is, the higher the probability that a learner can connect new concepts to the current conceptual systems he/she possesses. Developing mathematical proficiency enhances problem-solving abilities. When learners grasp the relations between a situation and a context, they learn how to use a precise method to decipher a problem.

The beliefs underlying a child-centred curriculum are portrayed in the diagram below:

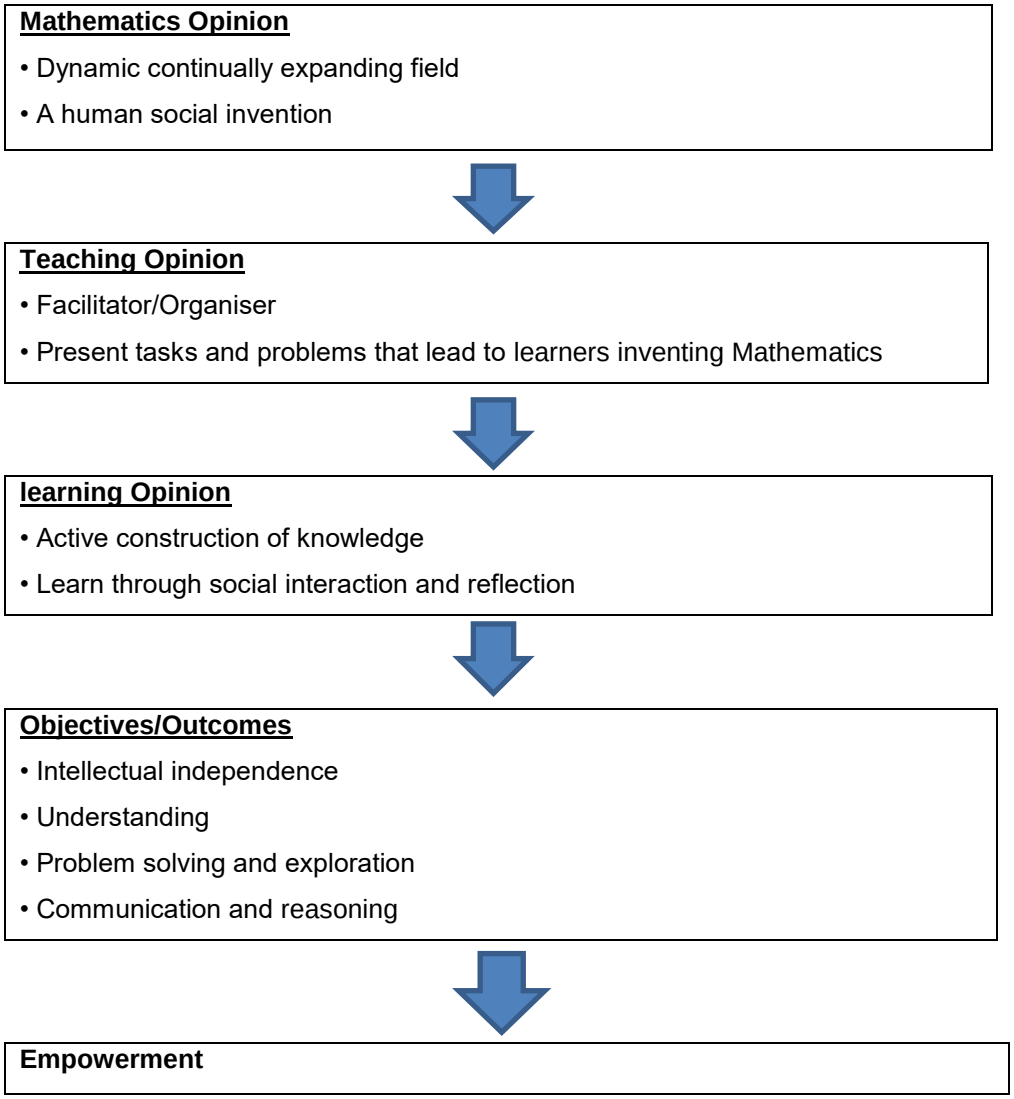


Figure 3. Beliefs underlying child centered curriculum.

(Source: Papandayan 2009)

In summation, mathematics is a worldwide, utilitarian subject - so much a part of modern life that anyone who wishes to be a fully participating member of society must know basic mathematics; hence the need to teach school mathematics.

2.3. Online Mathematics games

Rapid advancement in Technology has renewed interest in the utilisation of online Mathematics games when teaching Mathematics. Advocates of incorporating

technology to explain mathematics, such as Hardman (2005), Wiersum (2012), Chick et al. (2001), Polly. (2012), Stott et al. (2013), Bokhove and Drijvers (2010) point to studies that technology such as computers can develop problem-solving situations. Using computers allows the learners to master concepts quickly thus allowing more time on building conceptual understanding (Hardman, 2005:1) and can assist in developing a deeper understanding of algebraic ideas. Stott, Hewana, Koliti and Mase (2013:62) continue by saying that as the new online mathematics games continue to emerge and permeate all social strata, teachers have a perfect opportunity to enhance learners' understanding of Algebra while teaching with online mathematics games. Wiersum (2012:24) defines online mathematics games as (i) activities that are governed by rules, (ii) have a clear underlying structure to them and (iii) show specific cognitive objectives of mathematics. Online Mathematics games are simplified, operational models of real-life situations that provide learners with vicarious participation in a variety of roles and events. Online Mathematics games are believed to have the following traits/elements:

- Set rules which define the legitimate actions of the players
- A basic sequence and structure within which the action takes place
- Hindrances, such as players competing against each other
- Time limit

According to Prensky (2001:5-1) the key characteristics of online mathematics games are: "rules, goals and objectives, outcomes and feedback, conflict; and/or competition, challenge, opposition, interaction, and representation". Online mathematics games act as graphic tools that promote understanding on what is being taught. Online Mathematics games are thought to be effective tools for teaching difficult and complex procedures because of the following traits: Action instead of explanation; create personal motivation and satisfaction; accommodate multiple learning styles and skills; reinforce understanding skills and provide interactive and decision-making contexts (Paraskeva et al.,2010:499).

Online mathematics games can be vital building wedges to advance mathematically proficient amongst learners understanding basic concepts of mathematics (National Research Council, 2001:115). Pape and Tchoshanov (2010:119) propound that

teaching without online mathematics games, for example Dragon box, can produce inactive and unresponsive learners, which may lead to learners` failure to understand algebraic concepts. Bragg (2006:220) claims that online mathematics games foster better levels of comprehension and ignite the interest of learners through anticipation of competition, challenge and fun. In this regard, according to Polly (2012:81) online mathematics games may produce a favourable environment which might result in learners understanding Algebra well.

By using online mathematics games, teachers will be forming an abundant tangible learning environment, because of the notion that learners understand better what they see. The diagram below illustrates this point.

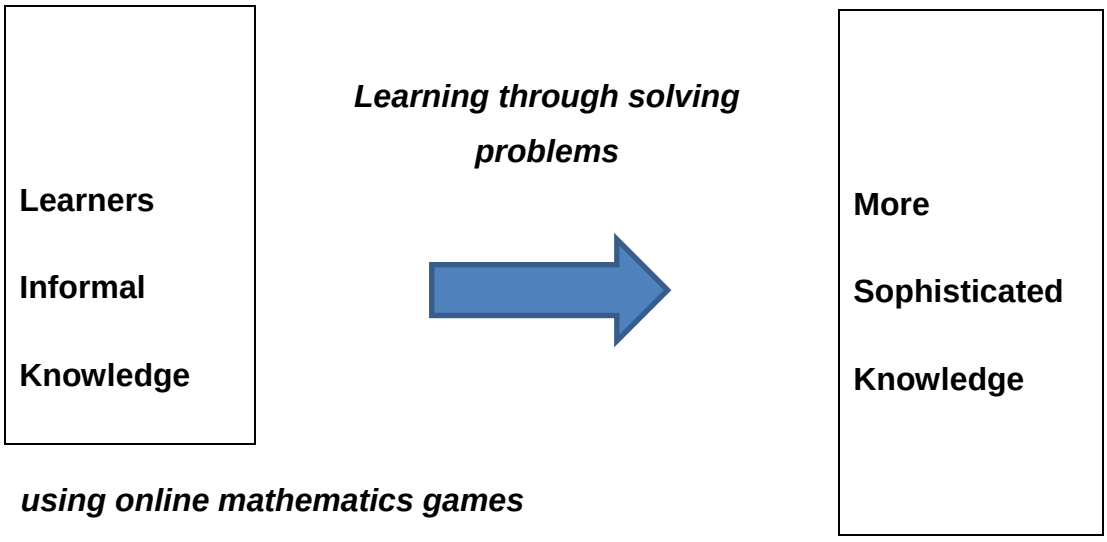


Figure 4. Learning through solving problems

In following the concepts illustrated above, learners in all likelihood will be building understanding. The learners` informal knowledge is moulded by online mathematics games into more sophisticated knowledge. The above assertion is supported by Murray (2001:28) who states that Mathematics is real. Learners learn better when they are utilizing their faculties; in this way, they should finish Mathematics undertakings using three –dimensional (sic) items to speak to the number under assessment. The use of online mathematics games is effective only when the online mathematics games are used to inspire learners to ponder as well as making connections between objects and intangible mathematics perceptions (Murray, 2001:28).

A major issue is whether teachers themselves know the significance of working with online mathematics games to explain algebra since, “effective mathematics teaching entails understanding what the learners know, what they need to learn and then challenging and supporting them to learn it well” (NCTM, 2000:16).

Learners like to compete, which motivates them to work out the total scores of the players and the difference in scores, to determine who the winner is. In teaching mathematics using online mathematics games, teachers should note that there are several goals of such play (Brewer, 2007:374). Goals of mathematics games are as follows: To understand the diverse ways in which numbers can be represented – for instance as numerals, dots or symbols, to count in various ways, to compare quantities of – for instance objects, spaces or symbols, to adopt others` perspectives, both cognitive and social, to think about strategies of game playing and to invent new rules and adapt to new rules invented by others.

2.3.1. Advantages of online Mathematics games.

Online mathematics games place the learner in the part of decision-maker, pushing learners through significantly harder difficulties, and learning happens by experimentation (Gee, 2003:2). Online mathematics games are very much sequenced in levels of expanding effort, unpredictability or speed. Accomplishment at resulting levels is dependent upon abilities aced at past levels and can be utilized as an instructive apparatus (Paraskeva et al., 2010:499). Above all, the pace of the exercises can be balanced for quicker or slower learners, beginners or specialists, to convey separated guidance (Gee, 2003:2).

Another explanation behind recommending games as great instructive devices is that they draw in learners, rousing them by means of fun, challenge, and moment input inside a total, intuitive virtual playing condition. Concerning the psycho-social factors that impact learning, it has been noticed that games can support learners who needs certainty. Also, Mitchell and Savill-Smith, (2004:17) express that unpredictable online mathematics games can possibly bolster intellectual handling and the improvement of vital abilities. As to scholarly execution, it is asserted that mind motions, related with navigational and spatial learning, increment when more puzzling games are played. Such expanded recurrence creates client learning and memory capacities,

and empowers more prominent scholarly, social and PC education aptitudes (Natale, 2002:26).

Bragg (2006:221) asserts that the ability of learners to reflect on the process as well as the actual result of the game instils an in-depth comprehension of the ideas being taught. With the use of online mathematics games such as Dragon box, learners are in a position to manipulate symbols and explore patterns. Figuring out how to look for examples and how to depict, decipher and expand them, structure some portion of doing arithmetic and thinking. Learners often lack impetus when it comes to learning Algebra, which may constrain their understanding and achievement. In this regard, online Mathematics games are intended to counter the weariness and dissatisfaction as far as the repetitive practice important for learners to comprehend mathematics aptitudes and ideas (Afari et al., 2012:131). The use of online mathematics games represents the conviction that learning can be agreeable and that reasoning is an energizing procedure.

Wiersum (2012:25) propounds that online Mathematics games allow learners to work at various degrees of intuition and to gain from one another. In a gathering of learners playing an online Mathematics game, one learner may be experiencing an idea for the first time; another might be building up his/her comprehension of the idea, while a third is uniting already learnt ideas. In this way the learners can work independently at their own pace; enhancing their understanding skills. Online mathematics games furnish learners with numerous open doors for decision-making and problem-solving. Through online mathematics games, learners can learn the processes engaged with taking care of an issue. In addition, online Mathematics games make another learning society that better relates with learners` propensities and interest (Mayer et al., 2002:172).

The other advantage of Online Mathematics games is that learners worry less about failing or making mistakes than they might with more traditional types of mathematics practice. Online mathematics games give chances to learners to study by themselves and about themselves. They can sense in a game what is easy and what is difficult. Learners experience possible consequences of trial and error. Online

Mathematics games reduce anxiety about mathematics and help learners develop a more positive attitude towards school work (Paraskeva, 2010:499).

According to Minero (2018) learning Mathematics used to be all rote memorisation and pencil to paper which seem disconnected from the real world today. The introduction of online Mathematics games may draw learners closer to everyday life in the digital world they know. Online Mathematics games, if used appropriately, serve as teaching aids which can help learners to make generalisations and to remember learnt concepts better. Bragg (2006:220) acknowledges that online mathematics games give some idea of the satisfaction that comes from a performance situation: one can gain a feeling of responsibility for the personal direction of the concept being taught. Online Mathematics games lead to mathematical discovery. When learners have various approaches to denote an idea, they can work with ways that are inherently important to them. As a result, they are most likely to understand the concepts being taught, according to Bragg (2006:221).

The notions above suggest that using online mathematics games in education is more than promising. It seems that games can teach children in a fun, engaging, persuading, intriguing and empowering way. Complex new information is conveyed, which is in any case too hard to even think about being instructed in a classroom: information can be balanced for various sorts of learning, enhancing vital aptitudes through experimentation, and trial-and-error. Both scholarly execution and relational relations are braced by the standards of winding education program.

2.3.2. Disadvantages of online Mathematics games

Potentially, use of online Mathematics games has disadvantages both for the teacher and the learners. I will discuss the disadvantages of using online Mathematics games in teaching Grade 8 Algebra. Using online Mathematics games to teach Algebra demands comprehension of the profits and drawbacks of utilizing gaming in the schoolroom (Adam, 2017). Identifying these drawbacks helps in considering which online Mathematics games best support Algebra lessons. Though online mathematics games may increase learner interest in school, they have impediments too; influencing learners both intellectually and physically. According to Adam (2017) it is easy for learners to become dependent on online mathematics

games which results in them playing for long hours; causing neck throbs, spinal pains, dull strain, fatigue and eye fatigue. Learners might need to play until they win or advance in the game.

Griffiths (2002:48) list the following drawbacks of teaching mathematics using online mathematics games. While online mathematics games are used to arouse interest, there is some evidence to indicate that learners can become interested in the game itself, not the subject matter which the online game represents. Anneta, Minogue, Holmes and Cheng (2009:80) maintain that at times the complexity and challenges learners face in virtual conditions cause learners to get occupied and disengaged in their learning. These sorts of learning tools may 'snare' learners without sustaining the learner interest desired. There is an idea among some teachers that learners are not getting anything intellectually; they are just sitting around idly as opposed to being taught. Online mathematics games seem to place considerable burden on the teacher to stay up with the latest content of the online game. The teacher has to determine whether the content of the online game is proper for explicit age and ability groups regardless of whether the online games are appropriate for the guidelines based accountability movement.

In the event that teachers are not as technically knowledgeable as their learners, it might expose a gap between educating and learning. Learners have become carefully capable to be digitally proficient, than the more seasoned ones. If the material is not mechanically exceptional, it might work contrarily for the learner and the teacher. Teaching by using online mathematics games may give the teacher less obligation and some of the time less command over the learning procedure. Games are time-consuming activities in the classroom. When schedules are organised for changing classes every 40 or 50 minutes, the cumulative effect of a game is lost by stop and start activities.

Anneta et al., (2009:80) maintain that lack of direct interaction and consequent feelings of social isolation are drawbacks for learners. Although there is interaction between learner and game, however one cannot question if there is a misconception. This lack of communication, discussion, interaction and feedback can lead to frustration, "Learners had to enter an explanation of what they saw but, again

received no feedback… essentially the learning objectives became a frustrating test and no fun" (Lowe, Lee, Cumming, Phillips & Lake, 2010:236).

Afari et al. (2012:131) claim that online mathematics games have the potential to bring learners into the learning process and to encourage them to participate through a more interactive environment. But teachers must locate as well as identify suitable online mathematics games for their instructive appropriateness and decide precisely how they can bolster their educating regarding the different cognitive developmental stages of the learners.

2.4. What is Algebra?

For purposes of this research, it is essential to have a closer look at what Algebra entails. Algebra is the major language of Mathematics. Blanton (2008) defines algebra as a strand in Mathematics, in which images are utilized to denote quantities. Algebra is the investigation of arithmetic images and the standards for controlling these images; it is a binding together string of practically the entirety of mathematics. Algebra is the means for learners to shorten large amounts of information into well-organized mathematical reports. Algebra includes everything from elementary equation solving to the study of abstractions. Algebra uses four basic operations $(\div, \times, -, +)$ like arithmetic but algebra has an element of the unknown and it makes use of symbols.

2.4.1. Requirements for Algebra in a curriculum

Vermeulen (2007:16) cites the South African National Curriculum Statement (NCS) for Mathematics and holds the view that it would appear that in order to promote successful learning and understanding of Algebra, the curriculum should:

> Enable learners to experience and appreciate algebra as generalised arithmetic, in order to accomplish this, the curriculum must promote learners to experience and appreciate algebra as a language used to express generalisation of patterns and procedures, thorough understanding the semantics and syntax of this language, including proper understanding

of the meaning and function of letter symbols, algebraic expressions and equations and manipulations performed upon them. The curriculum should enable learners to use and appreciate algebra as a means to describe relations between variables. Lastly, the curriculum should enable learners to use and appreciate algebra as a tool to solve problems, inside and outside mathematics, often through a modelling process.

2.4.2. Algebraic thinking

According to Van de Walle (2013:254) algebraic reasoning or mathematical thinking includes shaping generalisations (for instance the speculation that $a + b = b + a$ tells us that $83 + 27 = 27 + 83$ without figuring the totals on each side of the equivalent sign) from encounters with number and calculations; formalizing these thoughts with the utilization of an important image framework and investigating the ideas of design and capacity. Seeley and Schielack (2008:266) go further, positing that algebraic thinking overruns the entirety mathematics and is basic for making arithmetic helpful in everyday life. In looking at algebraic thinking, Seeley and Schielack (2008:266) state, “For learners to be set up to prevail in algebra, probably the best device they can have is a profound comprehension of the number framework, its activities and the properties identified with those tasks”.

Kaput (1999:135) describes five differences of algebraic reasoning as follows generalization from arithmetic and from designs in the entirety of mathematics, significant utilization of symbol, investigation of structure in the number framework, investigation of examples and capacities and procedure of demonstrating, incorporating the initial four records.

Blanton (2008) aptly states that algebra is designed to help learners see and describe mathematical structure and relations for which they have constructed meaning. Learners construct meaning as they gather information, create and express guesses about the relations and fabricate contentions to help their guesses. Algebra in the schoolroom should intently show how variable based mathematics is utilized in reality.

For learners to accomplish access to, and accomplishment in, the proper investigation of algebra, they have to accomplish familiarity with utilizing mathematics reasoning devices and casual mathematics thoughts (Kriegler & Lee, 2007). Mathematical tools are explanatory propensities for mind. They are sorted around three points: critical thinking abilities, portrayal aptitudes and quantitative thinking aptitudes. Major algebraic thoughts speak to the substance area wherein mathematics thinking apparatus are formed. These ideas are investigated through three focal points, polynomial mathematics as summed up number juggling, variable based mathematics as a language and algebra as a device for capacities and numerical demonstrations.

Kriegler et al. (2007) go on to say that “algebraic thinking” has become a catch-all expression for teaching and learning mathematics that equip learners with the basic reasoning abilities expected to completely take an interest in our popularity based society and for fruitful involvement with variable based mathematics. Algebra is a language and to fathom this language, one must comprehend the idea of a variable and variable articulation, and the implications of results. It includes suitable utilization of properties of the number framework. Algebra requires the capacity to peruse, compose and control the two numbers and emblematic portrayals in formulae, articulation, equations and disparities. Being familiar with the language of algebra requires understanding the importance of its jargon (images and factors) and adaptability to utilize the syntax of its principles (mathematical properties and conventions).

Algebra might be seen as an instrument for capacities and arithmetic demonstrating. Through this viewpoint, arithmetical reasoning shows learners the genuine uses and pertinence of variable based mathematics (Herbert & Brown, 1997).

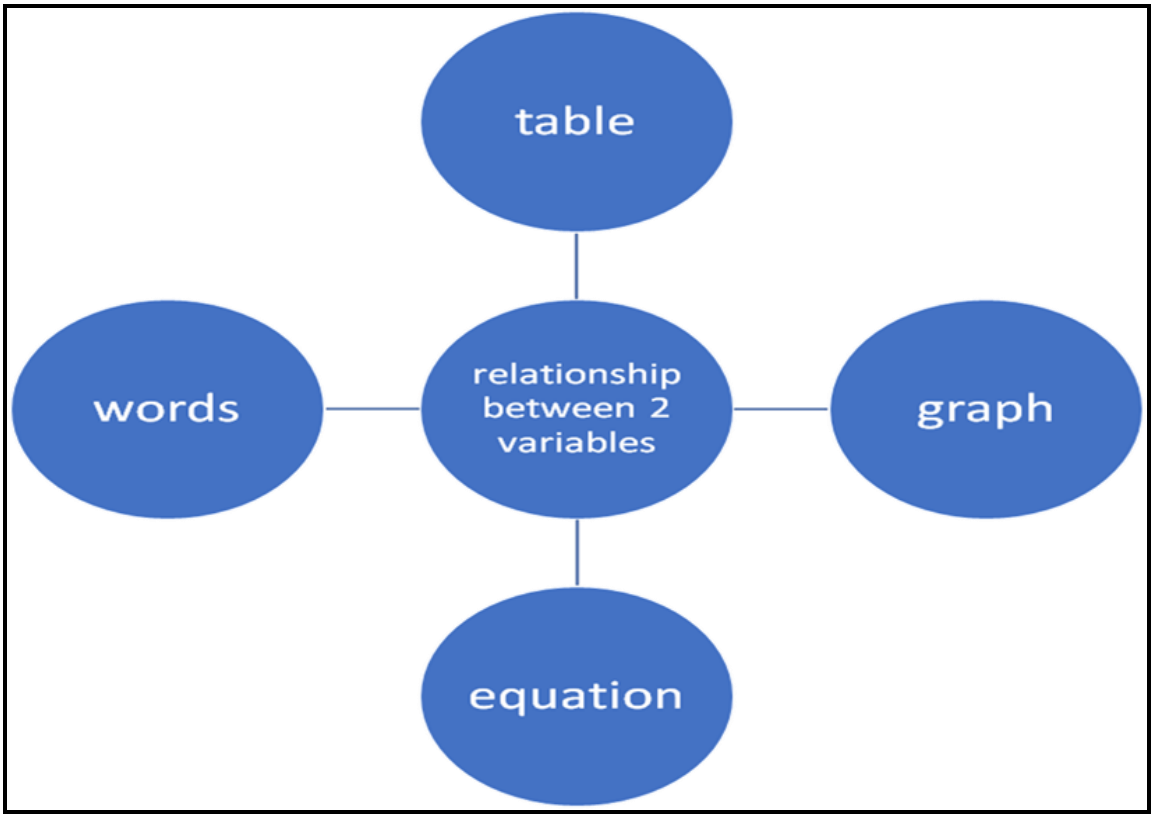


Figure 5. Relations between 2 variables

(Source: Primary data).

Looking for, communicating and generalizing patterns and rules in real world contexts; representing mathematical ideas using equations, tables and diagrams; working with input and output patterns and creating coordinate charting procedures are numerical exercises that fabricate variable based mathematics related abilities (Friel, Rachlin, & Doyle, 2001).

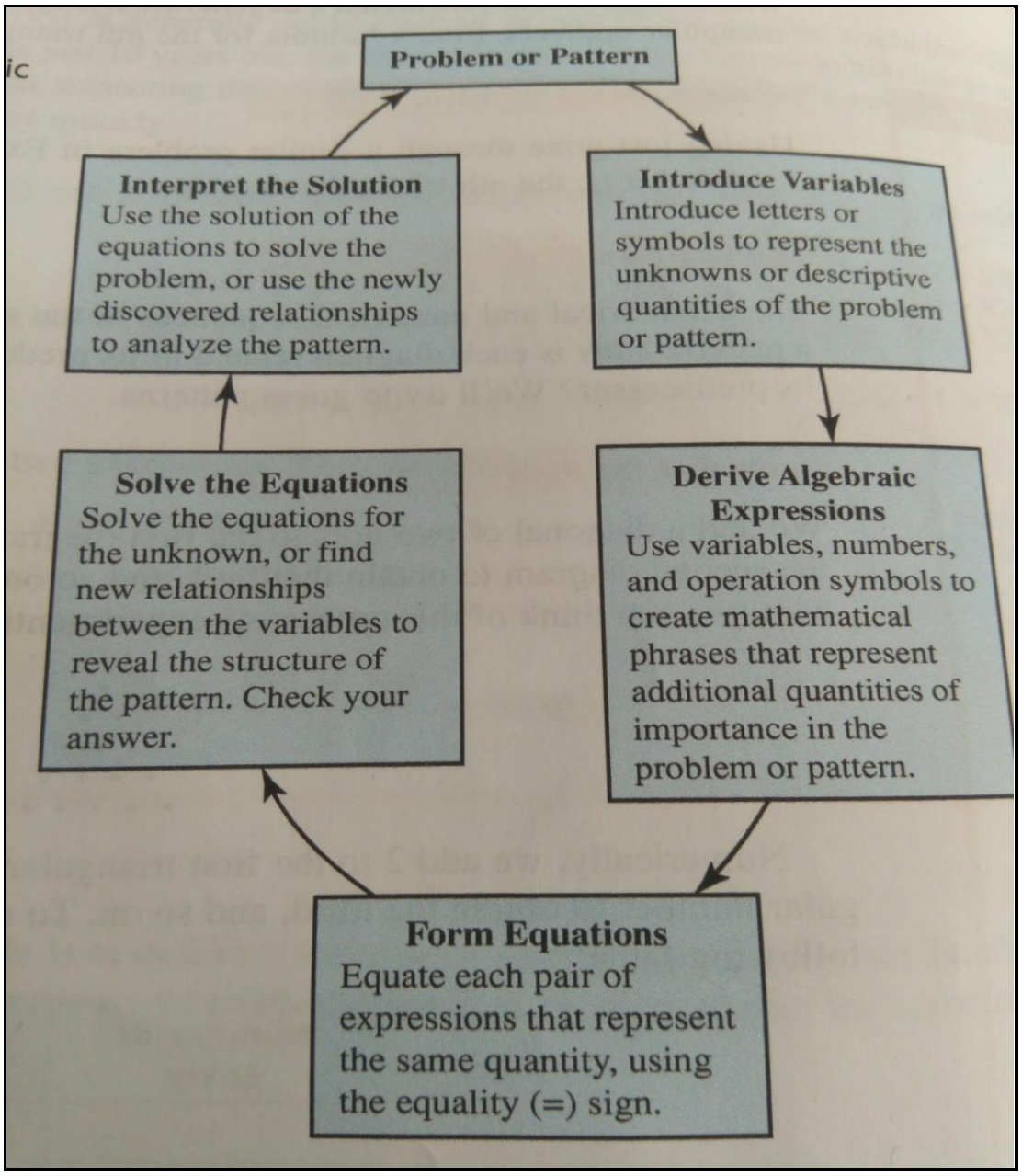


Figure 6. Steps in algebraic reasoning (Long and De Temple, 2015)

Understanding Algebra includes framing speculations from experience with number and computation, formalizing these thoughts with the utilization of an meaningful symbol system and investigating the idea of patterns (Van de Walle et al., 2013:254). Algebra permits learners to express generality in written form by using symbolic notation: the symbolic representation explores relations further and is a basis for justifying, proving or predicting. According to Long and De Temple (2015) learners can comprehend a bit of algebra if they can do all of the accompanying things:

- Clarify algebraic ideas and realities as far as less difficult ideas and facts.
- Effectively make sensible associations between various realities and ideas.
- Recognise the association when you experience something (inside or outside of Mathematics) that is near to the Algebra you understand.
- Distinguish the standards in the given bit of variable based mathematics that make everything work.

Learners must be guided in such a way that they continuously take a stab at understanding rather than remembrance (Friel, Rachlin & Doyle, 2001).

2.4.3. Why are learners unsuccessful in Algebra?

According to Van de Walle et al. (2013:254) learners are unsuccessful in Algebra because:

(i) they do not know what the letter symbols used in algebra (such as $a, b, x, y\ etc$) , conjoining or closure, such as ($2a + 3b = 5ab\ or\ 3 + x = 3x or\ x + y = xy$) mean, simplifications such as $3x - x = 3$,

(ii) learners do not know what equations such as $2a + 3 = 7$ mean, how they are different from expressions such as $2a + 2$, or what the solution of an equation means. Doerr (2004:271) propounded that learners are unsuccessful in algebra could be based on the fact that they do not have a strong understanding of the symbols they are using. For example: The most effective method to decipher images or numbers that are composed to one another can be harmful for learners? In our number framework, the symbol "27" implies "*twenty-seven*". Nevertheless, in the language of algebra, the articulation "$27x$" means "*multiply 27 by* x". In this case the learners would have a misconception that x is the symbol for multiplication not a variable".

Blanton (2008) claims that imagery, particularly images including uniformity and factors, must be surely known for learners to be effective in algebra. The experience of manipulating symbols is too often devoid of meaning; resulting in an aversion to algebra. As indicated by Van de Walle et al. (2013:257) images represents genuine occasions and should be valuable devices for taking care of significant issues that guide in decision-making (e.g. at what degree do a given sum of representatives

need to work to complete the undertaking on schedule?). Learners cannot comprehend such inquiries without understanding instructions on the equal sign and variables. For example: The factors utilized in algebra take on various implications, contingent upon setting. In the condition $4 + x = 6$, "x" is an unknown, and “2” is the answer to the condition. But in the report $A(x + y) = Ax + Ay$, "x" and "y" are used to sum up a pattern. If learners fail to understand the context, they have difficulties in solving algebraic expressions and equations (Vermeulen, 2000).

Dragon box makes it easier to convey algebraic concepts to learners as they play the game. The Rand Mathematics Study Panel (2003) states that explorations dating from 1975 to the current day shows clearly that “=” (the equivalent symbol) is a figure poorly comprehended by algebra learners. When learners fail to comprehend the equivalent sign, they commonly experience issues when it is experienced in arithmetical articulations (Van de Walle et al., 2013:258). In the event, comprehending a straightforward condition, for example $5x - 24 = 81$ requires learners to understand that the two sides of the equivalent sign as comparable articulations. Mann (2004) posits that helping learners comprehend the possibility of comparability can be grown solidly utilizing material articles and representations to strengthen the equalization thought of the equal sign. The equilibrium is a solid tool that can assist learners with getting on the off chance that you include or take away an incentive from one side, you should include or take away an equivalent incentive from the opposite side to keep the condition well-adjusted.

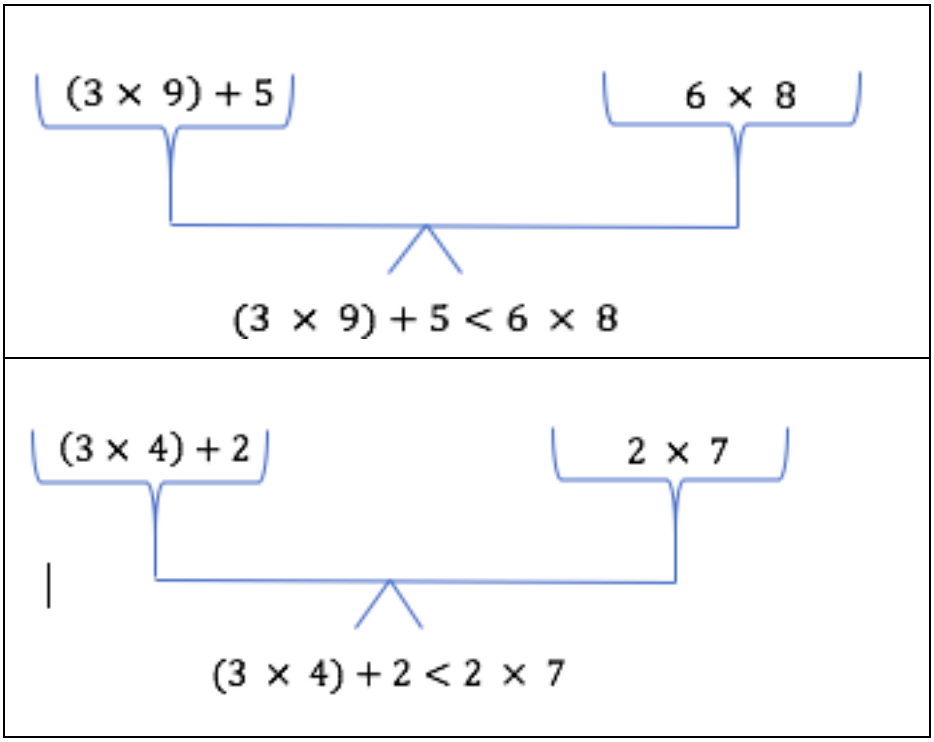


Figure 7. Algebraic equivalence Diagram (Mann, 2004)

By using online mathematics games, it becomes simpler for the learners to comprehend the idea of equivalence through play. Star and Selfert (2006:288) propound that realizing how to improve and perceive proportionate articulations are basic aptitudes to working algebraically.

Figuring out how to look for design and to depict, decipher and broaden these examples is a piece of doing arithmetic and thinking mathematically. A huge idea in working with rehashing designs is for learners to recognise the centre of the example and to utilize information on the centre to expand the pattern (Warren & Cooper, 2008). The center of a rehashing repeating pattern is the series of components that rehashes. For instance learners ought to perceive that the shading design ‘blue, blue, red, blue, blue, red’ is similar in form as ‘clap, clap, step, clap, clap, step’. Realising that the example above could be depicted as having the structures AABAAB is for learners an early prologue to the force of Algebra (Lambdin & Lynch, 2005:316). With sequences, learners extend patterns and search for speculation or

an algebraic connection that will mention to them what the example will be any point en route.

Pournara et al. (2016) describe understanding as the most fundamental goal of Mathematics instruction. But algebra with its signs, symbols and substitutions can leave learners` bored and confused. Star and Selfert (2006:288) assert that algebra can be a wellspring of significant disarray and negative perspectives among learners. One reason for this state of affairs is that learners seem to find algebra difficult to understand. Algebra requires abstract thinking, a challenging new skill for many grade 8 learners. Grade 8 learners often make the following typical errors; such as conjoining or closure (e.g. $3 + x = 3x\ or\ x + y = xy$), overgeneralisation of the distributive property (e.g. $\sqrt{x} + y = \sqrt{x} + \sqrt{y}$) , partial presentation of the distributive property (e.g. $2(x + y) = 2x + y\ or\ \frac{4x+6}{2} = 2x + 6$) and change an mathematical articulation into an equation (Vermeulen, 2000). Algebra moves learners beyond an emphasis on arithmetic operations, to concentrate on the utilization of symbols to characterize members and express mathematics relations (Star & Selfert, 2006:289).

Research was conducted by using Increasing Competence and Confidence in Algebra and Multiplicative Structures (ICCAMS). In investigating changes in learners` comprehension of algebra, it was discovered that (i) more learners were accomplishing poor grades and (ii) there was little change in the sort of mistakes learners made and (iii) understanding of algebra remained weak (Hodgen, Brown, Coe & Kuchemann, 2012). Pournara et al. (2016) state that, in spite of the total sum of what has been realized, algebra stays a generous impediment for some learners of high school Mathematics; as borne out in the low execution of South African learners on the Ideas in Optional Mathematics and Science item 45 years after they were first developed.

The Department of Basic Education (2012) research discoveries show that numerous learners in FET experience issues with parts of fundamental algebra because of their inability to understand basic grade 8 algebra. This assertion is supported by comments of grade 12 examiners in 2012 who state that a considerable lot of the blunders made in noting paper 1 have their beginnings in

helpless comprehension of the rudiments and fundamental skills instructed in prior grades; for instance controlling algebraic images (Department of Basic Education, 2012). This research seeks to bridge this gap: allowing learners to understand basic algebraic concepts through use of online mathematics games. As indicated by Van de Walle et al. (2013:255), for learners to be set up to prevail in algebra, probably the best device they can have is a profound comprehension of the number framework, its activities and the properties identified with those tasks. A huge piece of comprehending mathematics is the learner's capacity to impart numerically; so it is imperative to utilize suitable phrasing in instructing algebra.

According to Mascolo (2009) the task of mastering algebra requires facility with the rules governing the use of these signs (=, variable). The signs and symbols that constitute algebra, function as a vehicle that mediates the operations performed when performing algebra. With respect to any given learner, these meditational means exist within the cultural activity that predates the learner. The task assists the learner to gain entry into the requisite system of meditational means. When learners gain mastery of the use of meditational means that define the practice of algebra, they are able to think algebraically (Mascolo, 2009).

2.4.4. Other factors which might lead to Algebra understanding, through playing online Mathematics games

Online Mathematics games create and promote a learning environment that can instil love and appreciation for Algebra (Paraskeva et al., 2010:499). Online mathematics games foster a motivating and conducive learning environment which improves every learner`s learning attitude and understanding skills, according to NCTM (2000:19). Gee (2003:2) claims that learners often feel that they are not capable, which can result in an undesirable approach towards mathematics. Online mathematics games can motivate learners to strengthen new concepts and relations by helping the learner to identify such concepts in everyday life at home. Afari, Aldrie and Fraser (2012) postulate that online mathematics games can bring learners closer to the learning process as well as encouraging them to participate through a more interactive environment.

Online Mathematics games can lead learners to work above their normal level. The game situation, according to Blanton (2008) frees learners from rote learning, memorization, textbook or obedience pedagogy, doing exactly what the teacher wants done. Learners find they can think freely, solve puzzles independently and find their own areas of preference within mathematics. Online mathematics games invite learners to practise without feeling the work is drudgery. Learners can practise in algebra more than they would be expected to do if they were faced with conventional textbook exercises (Darby & Lang, 2019). Learners can practise and enjoy Algebra because their attention is on carrying out a 'move' in the game and not on how much work they have to do. Afari et al. (2012) in support of the above statement, claim that online mathematics games allow learners to develop eye-hand coordination, concentration levels, memory, understand skills, and communicate, and use algebraic language with confidence.

2.5. Previous research on online Mathematics games

Zoltan Dienes 1969, cited in Moyer (2001:177) persuaded researchers that the utilization of different portrayals of an idea, or "multiple embodiments" was expected to help learners` comprehension. Recently, online mathematics games have been recommended as a prospective learning tool by both instructive analysis (Barab, Thomas, Dodge, Carteaux and Tuzun, 2005; Gee, 2003; Squire, 2003) and online mathematics games designers (e.g. Aldrich, 2004; Prensky, 2001). The most mentioned opinions held by these researchers for integrating online mathematics games into education are that online mathematics games stimulate extraordinary commitment in learners (Malone, 1981; Rieber, 1996) and empower dynamic learning (Garris, Ahlers & Driskell, 2002). Exact proof exist that online mathematics games might be viable tools for improving learning and comprehension of intricate topics (Ricci, Salas & Cannon-Bowers, 1996). Online mathematics games can encourage joint effort among learners (Kaptelin & Cole, 2002). Moyer (2001:177) citing Piaget (1952) suggests that learners do not generally have the psychological development to have an understanding on conceptual mathematical ideas introduced in words or images alone: they need numerous encounters with solid materials and drawings for long term learning to take place.

According to Mji and Makgato (2006:253) a few examinations have detailed various weaknesses in the instructing and learning of mathematics. The Third International Mathematics and Science Study (TIMSS) conducted in 1995, in which South Africa partook with 41 others, the final results showed that South African mathematics learners came last, with an average score of 351. The average was fundamentally lower than the global standard of 513. TIMSS, conducted in 1999, uncovered that Grade 8 learners once again performed ineffectively. Their average score of 275 was fundamentally beneath the global average of 487. TIMSS directed in 2003 likewise showed no progress by South African mathematics learners (Mji & Makgato, 2006:253).

Several major reviews on online mathematics games Mahmoudi, Koushafar, Saribagloo and Pashavi, (2015:423) showed not at all vibrant connection between scholarly execution and utilization of online mathematics games. Skeptics about using online mathematics games for educational reasons assert that there is an absence of an empirically grounded system for coordinating online mathematics games into the classroom. Bringing online mathematics game into classrooms raises the same number of issues as it unravels. First, playing online mathematics games does not engage each learner. Second, learners might be occupied by game-playing and not accomplish the learning objectives. Learners may fall short in extricating proposed information from an entangled gaming condition (Mahmoudi et al., 2015:423).

Do online mathematics games truly cultivate an appealing, compelling learning involvement in schoolroom? Restricted explorations such as those led by Barab et al. (2005) and Squire (2003) were concluded to investigate the above inquiry. An ongoing survey of game-based educating research indicates that most gaming investigations center on adapting theoretically, including ideas, for example, general thinking, innovativeness, framework comprehension and decision making, which do not request exceptional information on branches of knowledge (Squire, 2003:50). Numerous recent online mathematics games that are utilized in encouraging learning need association with the educational plans. The subject matter in these online mathematics games is considered excessively broad and unfitting in satisfying existing educational programs. The present study, however, emphasizes the value of

online mathematics games in teaching by investigating the potential of online mathematics games to complement the constructivist foundations of CAPS and facilitate the instructing of mathematics ideas and aptitudes that are required by main subject guidelines.

Researchers, such as Barab et al. (2005) and Squire (2003) started to inspect what happened with learners and their educating procedures in game - based educational programs of mathematics. Online mathematics games have been utilized in education basically as instruments for supporting drill and practice, yet restricted exploration has been conducted into the viability of these games (Squire, 2003:50).

2.6. Online mathematics games used in this research

In this research, two online games were used: namely Dragon box and Algebra meltdown. These online mathematics games were designed to reinforce algebraic concepts. Quick execution inputs are given concerning learner activities: these criticisms involve marking the appropriate responses right/wrong. Each online mathematics game has score keeping and employs dynamic levels of difficulty – more difficulty issues were introduced at the more significant stage of the game (Gee, 2003:2). To succeed in the lower-level unit and continue to a more significant level, learners need to respond to all inquiries at the first level accurately. The numerous stages that the learner succeeds in, the higher the score he/she earns. Online mathematics games at each level expose learners to new abilities and allow them to practice this new range of abilities to a programmed degree of authority. Often the game itself proves so exciting that learners learn without realizing they are learning in the traditional sense of the word. Learners at that point proceed onward to another level, see that the old abilities have been tested then, and need to reconsider and adapt again (Gee, 2003:2).

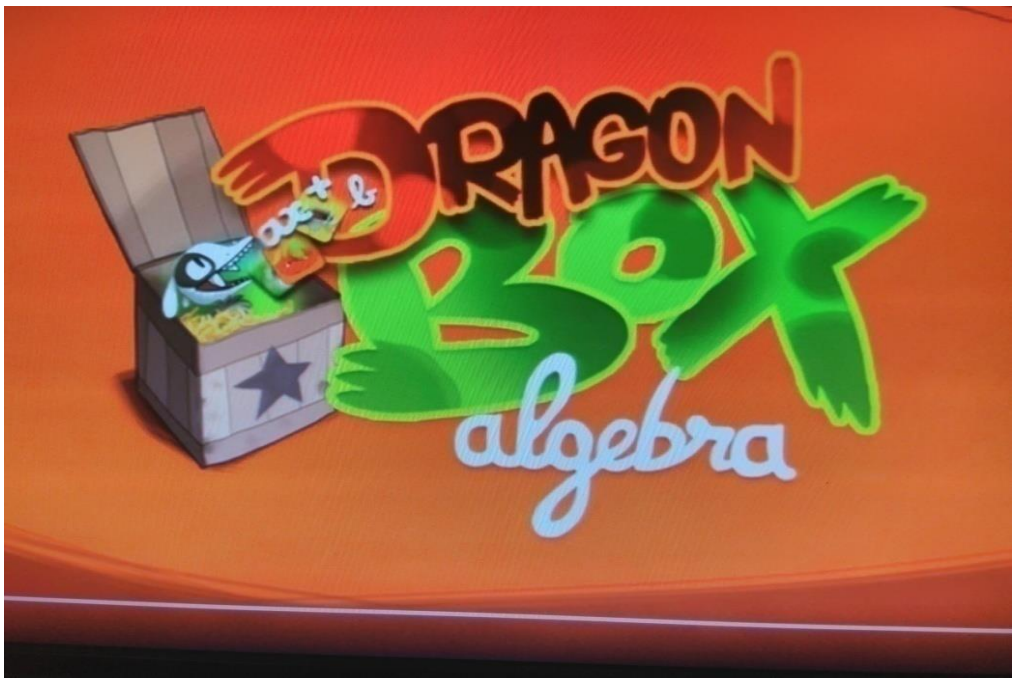
Playing games involves an endeavor to fit new data into existing openings or classes (absorption) and the procedure by which players adjust their current model to oblige new data. Online mathematics games involve learners in steady examinat5ion of abilities and techniques, testing and modification. A significant part of online mathematics games involves intellectual and meta-cognitive activities undertaken

while developing mastery. Evaluation of the outcomes of online mathematics games in this research should be a complete assessment of understanding, psychological, meta-cognitive and inspirational viewpoints.

2.6.1. Dragon box

Dragon box is one of the online mathematics games used to teach algebra during research. Pearce (2013) states the following about Dragon box:

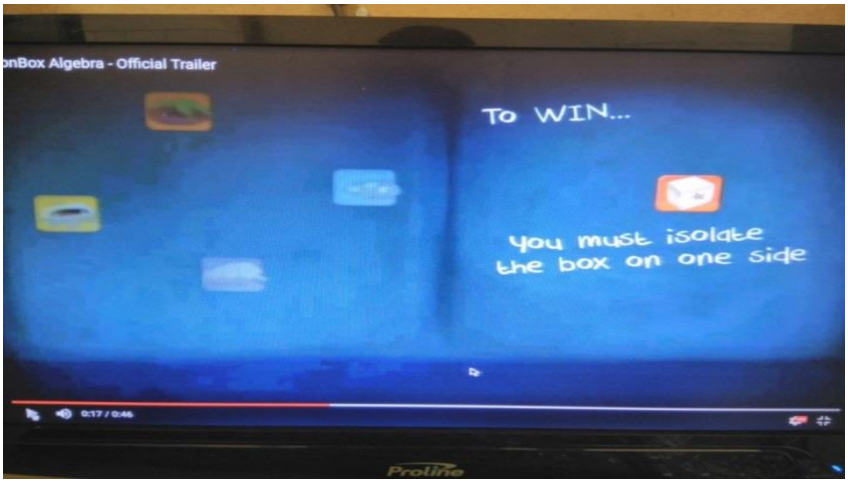
- it is intuitive, engaging and fun;
- It gives a head start in mathematics and algebra as well as conveying the rules of algebraic solving without any confusion;
- With Dragon box, algebra concepts are simplified into a simple game and it is an innovative educational game that through game play teaches learners concepts relating to solving algebraic equations;
- Dragon box covers the following algebra concepts: addition, multiplication and division;
- Dragon box utilizes a novel instructive technique dependent on disclosure and experimentation (Pearce, 2013).



Adapted from www.wewanttoknow.com

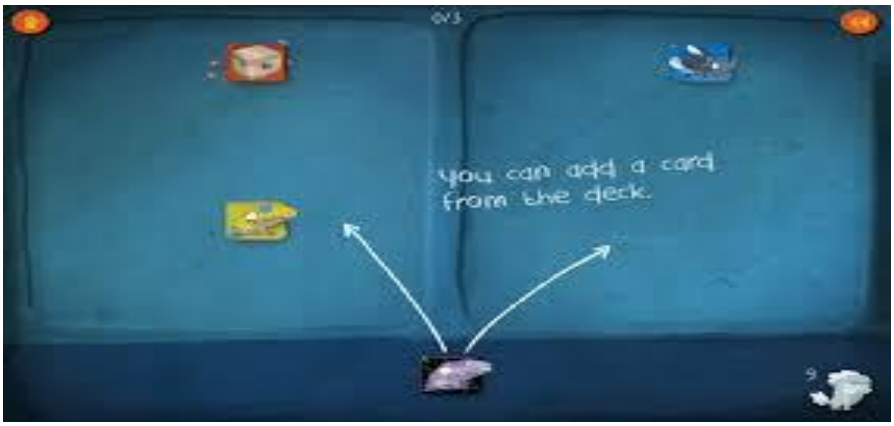
2.6.1.1. How is dragon box played?

By controlling cards and attempting to confine the Dragon box on the other of the online game, the learner progressively learns the tasks required to confine x on the other side of the linear equation. When playing the online game, the cards transform into variables and mathematics symbols. As learners progress through the levels, they earn dragons.



Adapted from www.wewanttoknow.com

There are two sides on this game the left side and the right side. On the screen there are cards and a box. For the player to win, the player needs to isolate the box on one side. It does not matter which side, as long the box is isolated. The moment the box is isolated the player will get three stars and the dragon becomes bigger with each level completed.



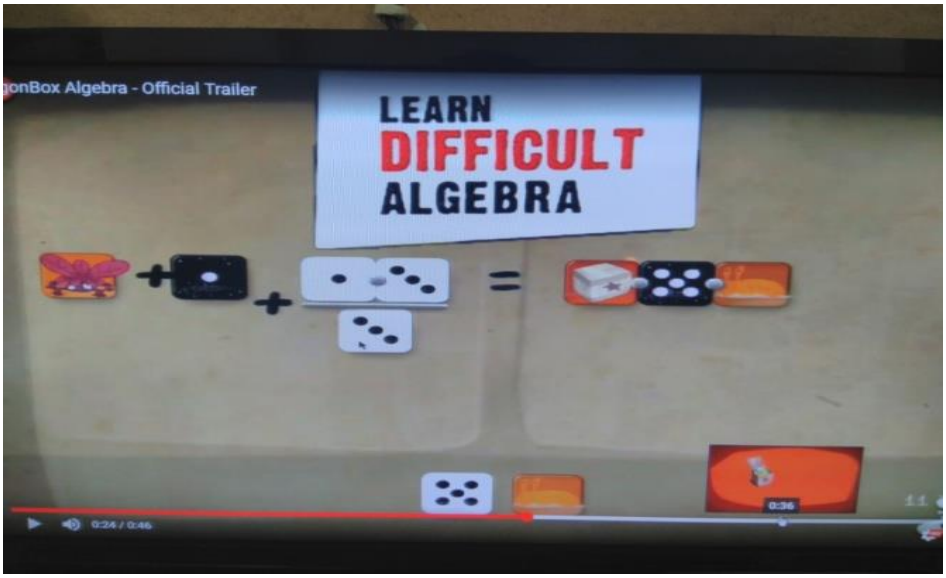
Adapted from www.wewanttoknow.com

To remove the cards on the screen the player needs to put identical cards on top of each other for them to disappear. If the player does not have identical cards, then the player needs to take the card from the deck.

Adapted from www.wewanttoknow.com

For the level depicted above, the player needs to solve the fractions first, multiplication and then isolate the box. The bottom fraction plus the identical cards if placed together will give you one. The sum will be as follows; $1 \times 1 \times 1 \times c \times 1 = c$ for the bottom fraction. For the top fraction the sum will be as follows; $-c \times 1 = -c$. To isolate the box, negative c will cancel each other with positive c thereby remaining with the box.

The cards are gradually replaced by numbers and factors; uncovering expansion, multiplication and division operations which the learner has been learning all through the online game. According to Pearce (2013) when playing dragon box, the levelled puzzles start simply, with graphics only. Then gradually some of the images are replaced with numbers, letters and mathematics operators as well as adding complexity until learners are solving algebra without the need of graphics.

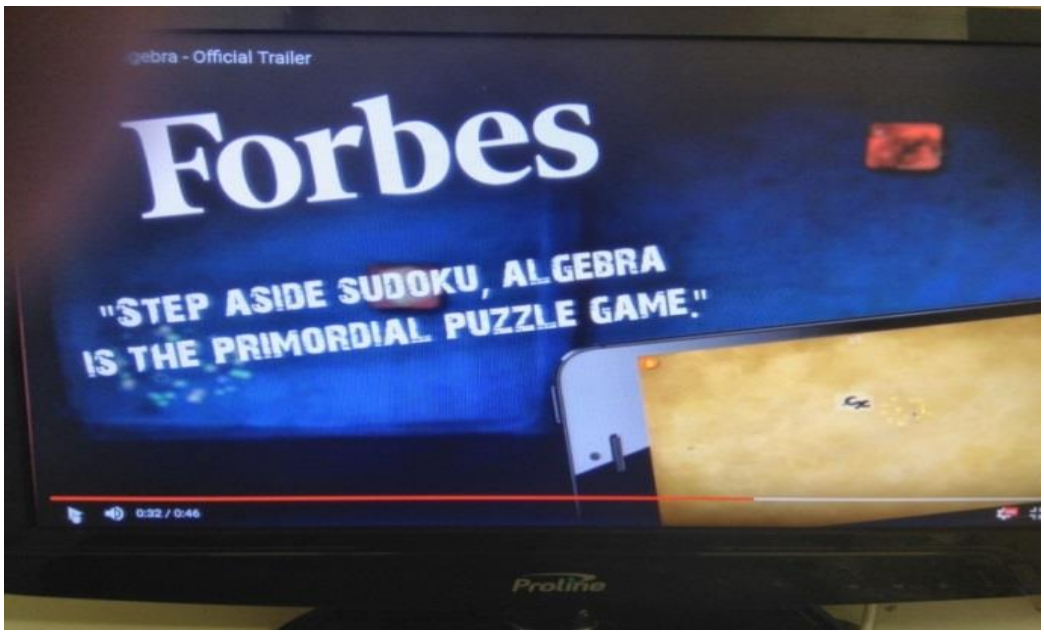


Adapted from www.wewanttoknow.com

Dragon box simplifies algebraic concepts into a simple game. It gives the learners the opportunity to get familiar with the basics of equation solving. Dragon box makes abstract algebraic concepts simple.

2.6.1.2. What are users saying about Dragon box?

The following are comments on dragon box derived from the following website https://www.commonsensemedia.org/app-reviews/dragonbox-algebra



Adapted from www.wewanttoknow.com

Dragon box gives the learners an opportunity to freshen up their own mathematics skills. By turning the rules of mathematics into the rules of the game, dragon box incentivises children to learn mathematics simply by playing. Because learners want to solve the algebraic problems, they are allowed to watch their dragons grow since they are given dragons after having completed each level.

Adapted from www.wewanttoknow.com

When learners encounter the dragon box ideas in class, they should have a connection and connections are everything in mathematics. However, something that will make this game rewarding is the addition of a brief lesson at the end of each chapter that relates the game to the vocabulary used in algebra. Learners who struggle in mathematics may not be able to make that connection intuitively if they lack mathematics sense.

2.6.2. Algebra Meltdown

Algebra Meltdown is another online mathematics game which was used to teach algebra in this research. Algebra Meltdown is an online mathematics game which can be used to solve linear equations. In this online game, learners unravel linear conditions by controlling them through the reactor. The game teaches learners to understand linear equations by using the number machine concept.

http://www.mangahigh.com/games/algebrameltdow

2.6.2.1. How the Algebra Meltdown works?

When learners play this game, Algebra Meltdown, it is as if they take control of a nuclear generator. The game takes the form of a laboratory, where the scientist requires different weights of atoms in the reactor and will throw a hissy-fit if left waiting for too long (Manga High, 2019).

http://www.mangahigh.com/games/algebrameltdown

At the beginning of each level, the researchers line up at the generator`s outlets, with speech bubbles over their heads to demonstrate the atoms (number) they want. The player is given an equation and the player needs to find the correct number of atoms

to put in the reactor. If the player chooses the wrong answer or takes too much time, the player will lose the points.

In reference to the literature already discussed earlier in this study (Wiersum, 2012; Pournara et al., 2016; Van de Walle et al., 2013; Department of Basic Education, 2012) online mathematics games are an effective way of conducting algebra lessons because they allow learners to formalize algebraic concepts by manipulating symbols and exploring concepts of pattern at their own pace; in many cases without realising that they are learning in the formal sense. Afari et al. (2012) support this assertion and indicate that online mathematics games have the potential to help learners understand algebra and to encourage them to participate through a more interactive environment.

2.7. Theoretical Framework

This research project was motivated by accepting the idea that a new device can incite strife inside the setting into which it is presented, prompting the change of the practices inside that setting. This research synthesizes Activity Theory, Socio-constructivism theory and Socio-Cultural hypothesis as logical tools to research whether the guidance of online mathematics games into a classroom transforms pedagogy. The researcher chose Activity theory, Socio-constructivism theory and Socio-Cultural hypothesis due to their understanding in the educating of mathematics. These theories agree on the notion that information is indistinguishable from training. Learners understand better by doing and mediating through tools and signs. In terms of these theories, learners are not inert but dynamic members. The diagram below summarizes the three theories to be discussed in this chapter.

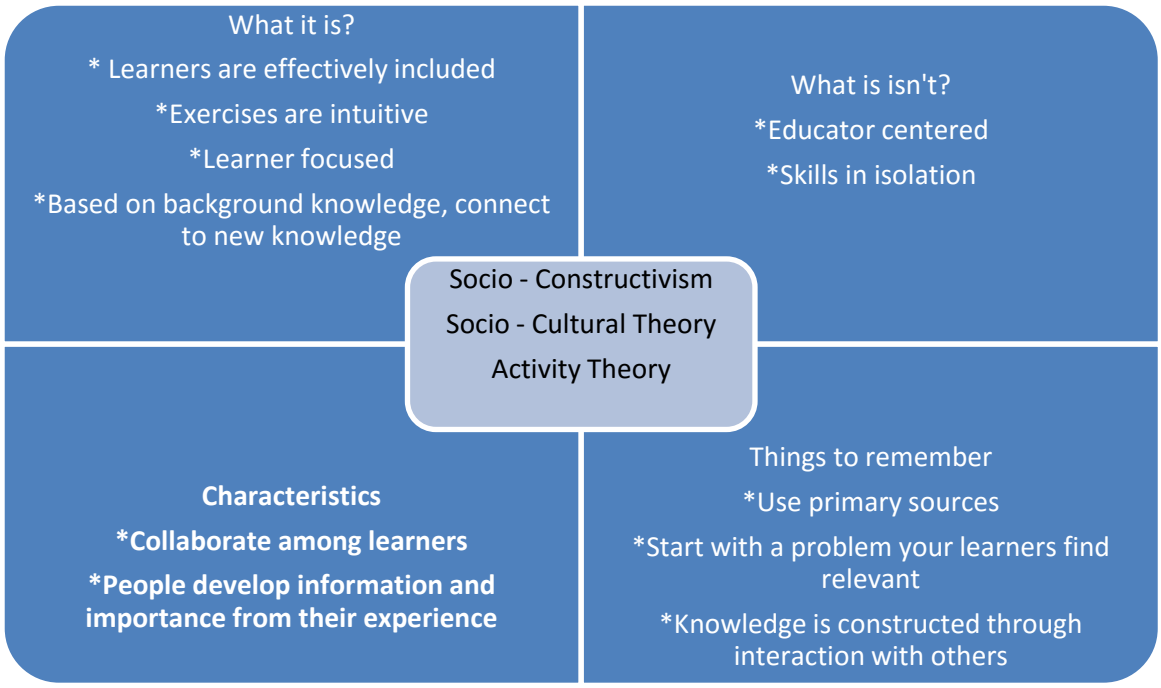


Figure 8. Summary of theories

(Source: Primary data)

2.7.1. Activity Theory

The researcher used Activity theory because this theory views the human cognizance as the result of our collaboration with others, objects and relics with regards to ordinary action (Kaptelinin & Nardi, 2006:345). Recent examination into mathematics education sees learners as dynamic members who build information by revamping their present methods of knowing and removing lucidness and importance from their experience. Moyer (2001:176) postulates that the abstract thinking processes of learners are firmly tied down in their solid views of the world; effectively utilizing online mathematical games permits learners to build up a collection of pictures that can be utilized in the psychological control of conceptual ideas.

Engestrom (1987) uses a triangular structure to show how activity occurs. He starts with Vygotsky`s three-sided model of conditioned direct association among motivation and reaction which exceeded by a complex intervened act communicated as triumvirate of a subject, object and mediating artefact (Kaptelinin & Nardi, 2006:345). Activity theory, since it is object oriented, helps learners engage more easily with algebra; helping learners to grasp key aspects of algebra. Activity theory

promotes a sense of belonging among learners and sharpens the mathematical acumen of learners.

Blunden (2009:3) propounds that Activity theory gives a strategy for comprehension and investigating a marvel, discovering examples and making deductions across associations. The object of Activity hypothesis is to comprehend the solidarity of cognizance and action with respect to online mathematical games. Activity theory defines consciousness as all the psychological operation including; recalling, choosing, grouping, generalising and abstracting as a result of our social collaboration with others and of our utilization of tools. Activity hypothesis advocates the investigation of artefacts as essential and indivisible parts of human operative (Kaptenin, 2005:10).

Activity theory is a hypothetical system for seeing how human movement is intervened by the two devices and social setting and can be a solid hypothetical reason for comprehending the impacts of online mathematics games on learners in the grade 8 Mathematics classrooms. Activity theory comprises of Subjects, the learners or groups, Objects, devices, which intercede a subject`s collaborations with an item, the network of a framework, rules and division of work. In a game, networks interceding activity through division of labour and mutual standards and desires (Paraskeva et al., 2010: 502). Activity theory can form a solid basis for developing online mathematics games that create concerted learning conditions, for example, networks of practices, where Mathematics learners cooperate with different subjects, articles and instruments of the online mathematics game, under stated guidelines and make networks through division of labour.

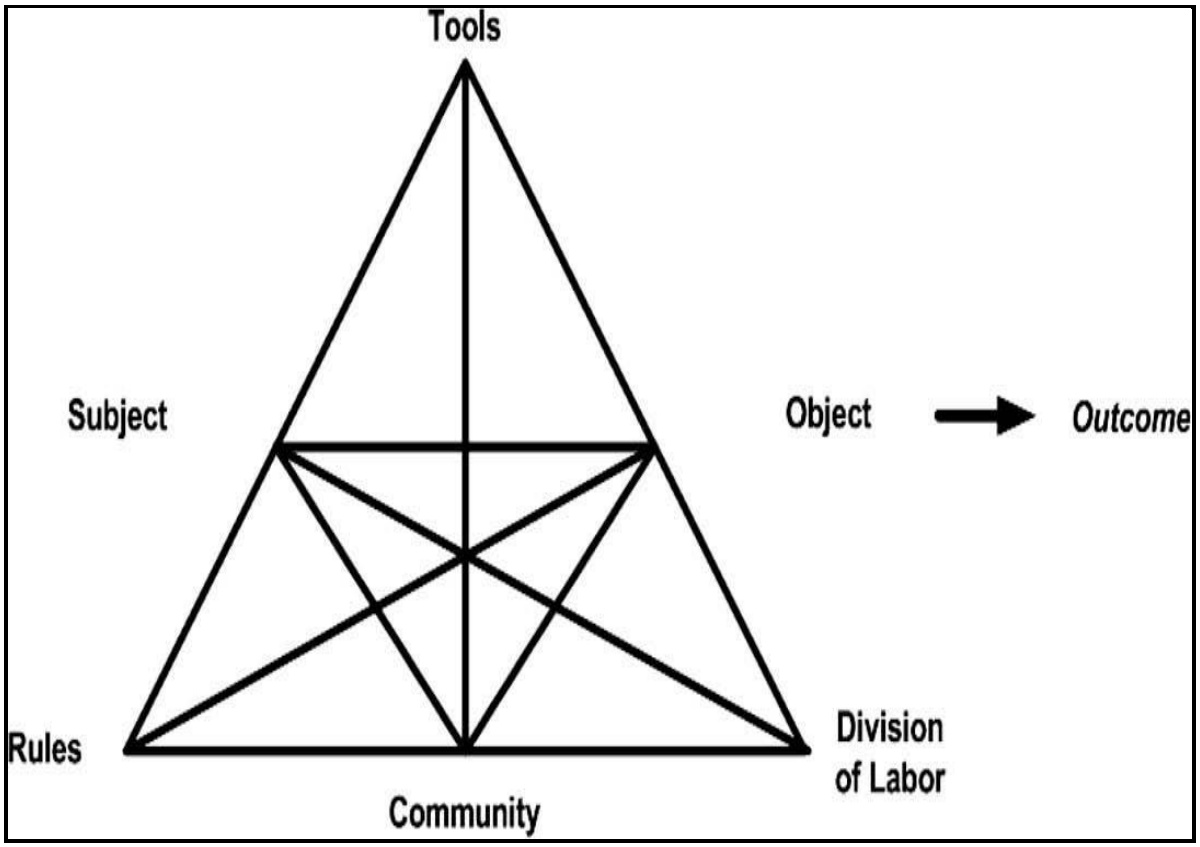


Figure 9. Activity theory diagram

(Source: Foot, 2001:10)

The action framework (Fig 10) is utilized by Activity scholars such as Engestrom (1987) to denote the communication among factors that influence upon and define the action. In an online mathematics game, the activity theory framework represents interactions among the various variables that impact a game action. The arrangement of a learning methodology in an instructive multiplayer game, in light of the action hypothesis, summarizes the fundamental communication among the variables of the Subjects, the Items, the Instruments, the Guidelines, the Network and the Division of Labour as they show up in the online mathematics game.

Engestrom (1987) uses the above model to explain how a wide range of factors work together to create an activity. The subjects are the grade 8 Mathematics learners who have difficulty in understanding algebra. The subjects used artefacts or instruments such as online mathematics games, Algebra Meltdown& Dragon box when learning Algebra. Learners need to follow the rules of Algebra Meltdown and

Dragon box to achieve the intended goal of understanding algebra. Engestrom and Sannino (2010:4) stipulate that learners learn something that was not yet there. The outcome and the route were both unknown to the learners but were figured out by participants themselves.

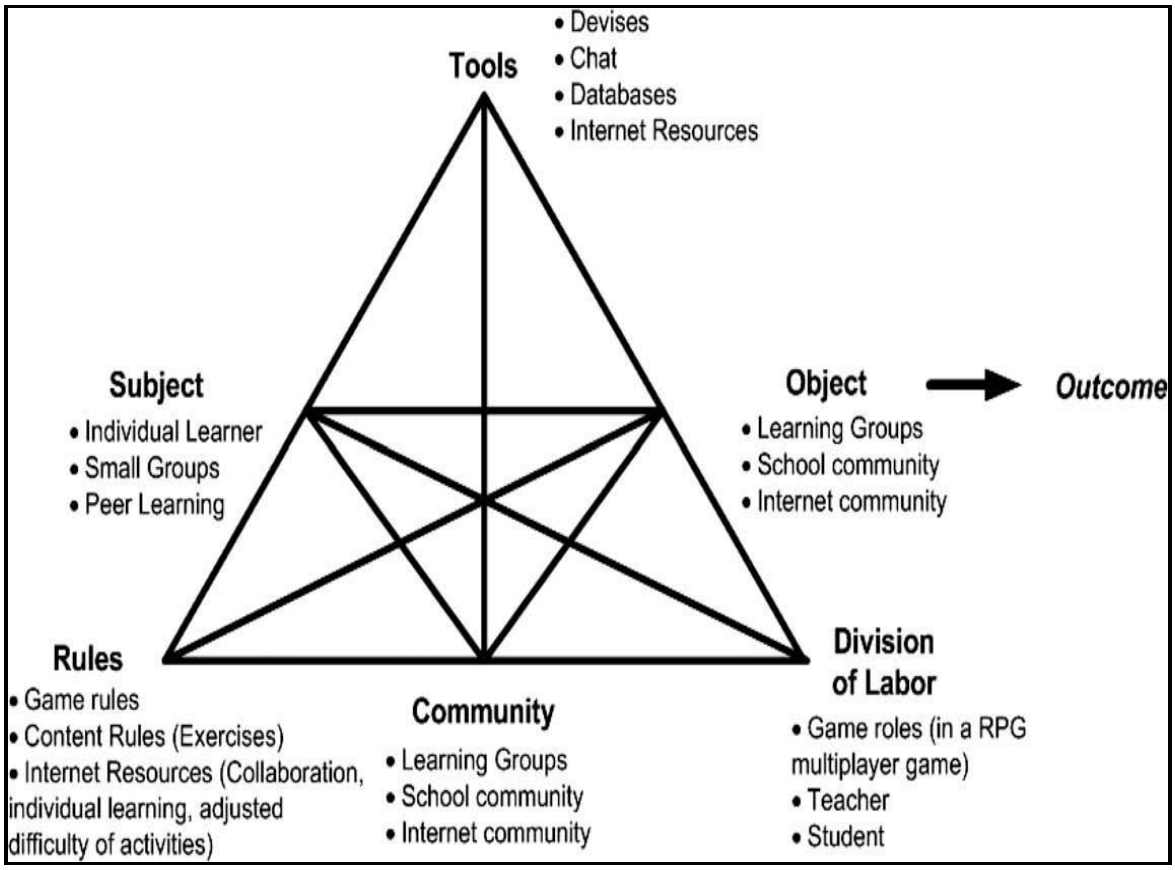


Figure 10. Activity framework in proposed multiplayer instructive games

(Source: Paraskeva, Mysirlaki & Papagianni, 2010: 502)

Fig 10 is an endeavour to characterize these components and their relations (Subjects, the Items, the Instruments, the Guidelines, the Network and the Division of Labour) and their components, so as to plan a portion of the online mathematics games parts with the learning strategy that would happen in an instructive mathematics multiplayer game.

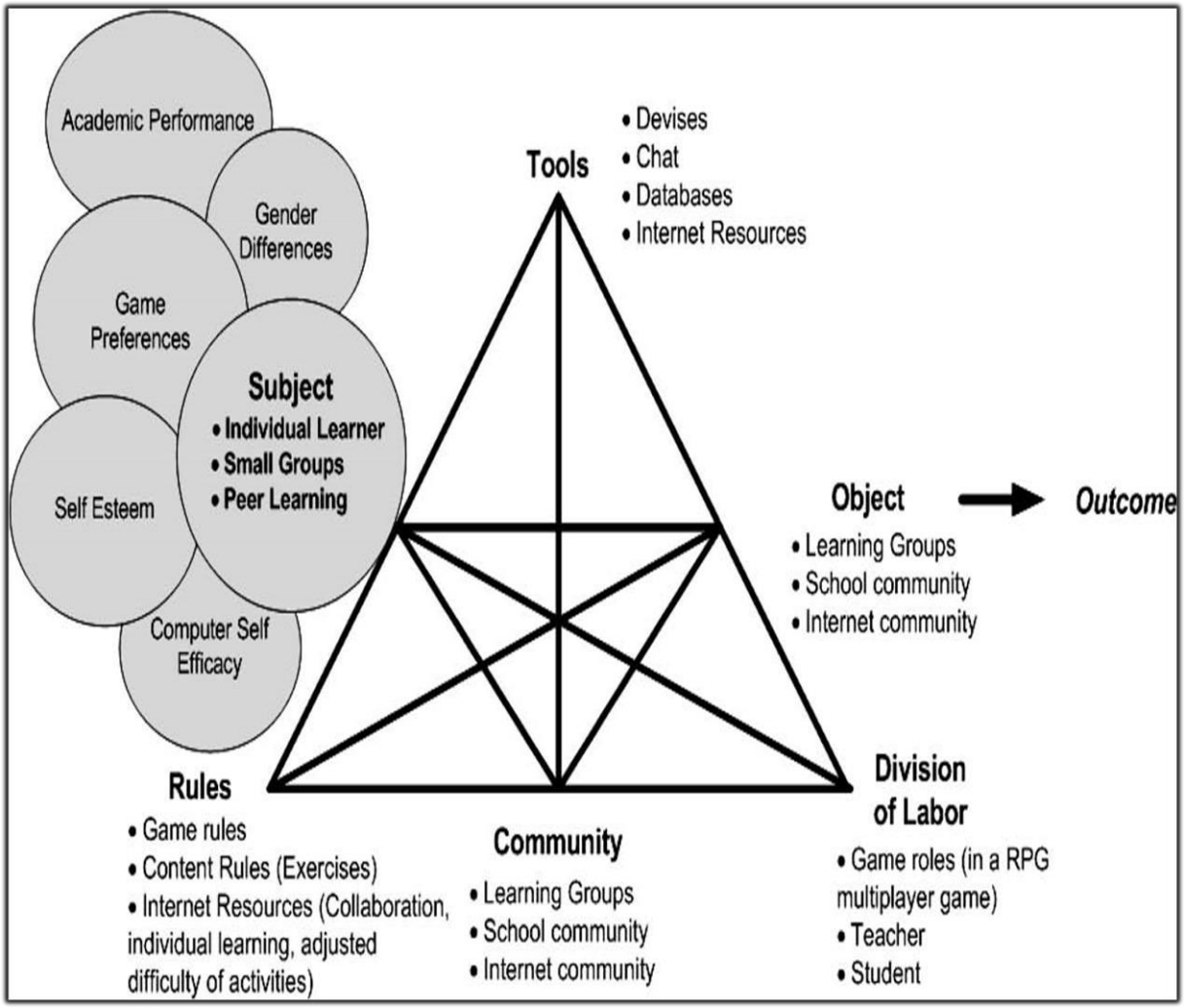


Figure 11. Activity framework in proposed multiplayer instructive games featuring subject elements

(Source: Paraskeva et al., 2010:503).

As introduced in Fig 3, we propose the improvement of multiplayer instructive games which depend on a movement hypothesis framework and featured by some significant psychosocial issues. This framework is considered as a multifarious interpersonal organization: subjects connect with various elements of the games, for example, those in Fig 3, to lead them to the instructive result. These games can be planned to be appealing for arithmetic learners, considering elements, for example sexual orientation contrasts and inclinations, with the end goal of creating PC self-adequacy and upgrading mathematics execution and confidence. From the socio-cultural viewpoint, this is the most significant point in comprehending how online mathematics games involve learners in instructive situations. The goal should be to

explore relations between factors, occasions, and intricate designs (Paraskeva et al., 2010: 505). The basic relations in action hypothesis as deliberated in this research are sketched out beneath:

- Subject: This is the focal point of the examination; for our motivations the subject is the learner.
- Mediating artefacts*:* These are apparatus that the subject utilizes to follow up on the item space. Altogether, these apparatus intervenes thought during the cooperation between the subject and the setting within an activity. Crucially, apparatus are not nonpartisan. They have built up history of utilization and convey inside them social implications (Kaptelinin, 2005: 10). It is critical to consider the object as both material and ideal; that is, the item contains inside it both the subject's inspiration (for going about) just as genuine material issue space is followed up on (Kaptelinin, 2005: 11). First, as the item embodies the rationale for the presence of the activity, and as it is the subject's inspiration that drives this, the researcher used interviews because they can be helpful apparatus for unloading thought processes. Second, what the instructor says and does in the classroom empowers us to build up an image of what it is that the person is dealing with in the exercise; subsequently, recognizable proof of the devices utilized by the educator empowers on to recognize the item in the framework.
- Rules: These are standards, conventions and social collaborations of the schoolroom, which drive the subject's activities (Hardman, 2005:259).
- Community: The subject is an individual from a network who takes up interest in following up on the mutual item. There is division of work inside the network, with obligations, assignments and control unceasingly being negotiated (Hardman, 2005:260). In this research, the network contains the educator and the learners who cooperate on a mutual issue in the mathematics classroom. In a wider sense, the teacher and learners are individuals from the network of the school.
- Division of labour alludes to the arrangement of duties, errands and force relations inside a mathematics classroom just as all through the school. The introduction of the online mathematics games can possibly compel a move in

the job of the instructor and learners, with learners working more as instructors of other learners in the mathematics classroom.

The advantages of Activity Theory are that it allows learners to take an interest and test in non-compromising situations; and it overcomes any barrier between the individual subjects and the social realty.

2.7.2. Socio-Cultural theory

Socio-cultural hypothesis is rooted in the idea that learning happens in social settings and is interceded by language and other image frameworks (John-Steiner & Mahn,1996:191). It is a hypothesis that considers play and other casual exercises as especially significant settings in which grown-ups give children new data, bolster their ability to advancement, and expand their applied comprehension (Ramani & Siegler, 2014:2). This hypothesis considers the significant part played by society in a person`s growth and the fact that learning is to a great extent subject to the social condition (Hall, 2007:94). Socio-cultural theory states that learning is not a matter of including and accumulating new ideas but increasing the current ones. Learning prompts changes in our plans. Social-culturalists believe that information is developed by learners and that learners themselves build their own comprehension through practice. Vygotsky emphasizes investigational learning and supporters learning by performance (Jaramillo, 1996:137). He contends that connotation originates from practice and emphasizes the significance of critical thinking solving in educating. This theory favours learning with understanding. It is believed that learners are not blank slates. Learners construct their own knowledge through integrated networks, that is, linking of ideas.

Educators should know that the manner by which learners believe is to a great extent impacted by each learner`s own discrete culture which informs each learner`s learning approach. We cannot separate learner culture from learning patterns. Educating people and their day by day life condition are interwoven. The attention ought to be on action inside socially collected and perceived circumstances.

Matusov and Hayes (2000:218) believe that more significant level capacities are rooted in socio-cultural theory and include rebuilding of lower level capacities functions by utilizing social signs and apparatus embraced by a general public. As people, we see the need and make approaches to make our lives simpler. At that point we show and educate others through social association and by overriding the educating procedure with social instruments. In socio-cultural hypothesis assets are regularly alluded to as “meditational means or cultural tools” (Forberg & Arnseth, 2009: 157). Utilizing social instruments, people are having the option to accomplish objectives that are hard to accomplish and raise the individual over his/her surroundings. This ladder to learning links well with Activity Theory which involves interaction and mediation of tools. Vygotsky views a higher mental capacity particularly as a social type of adjustment which includes an association with fundamental mental capacities as well as the reorganization of them (Levykh, 2008:86). Vygotsky upholds that such reorganization is possible just by using social devices.

2.7.3. Socio-Constructivism

This exploration utilized a constructivist model to analyse the ways learners based on their psychological structures through online mathematical games. The online mathematics games were chosen to create intellectual disequilibrium within the learners’ existing theoretical structures; expecting them to oblige new reasonable understandings and possibly attain psychological harmony. According to Hein (2007:1) constructivism is a hypothesis of learning founded on the possibility that information is developed by the knower, in light of the mental action. Learners develop information for themselves; each learner separately and socially builds significance as the person learns. This view is supported by Rummel (2008:80) who states that constructivism is a functioning procedure where learners build and disguise new ideas, thoughts and information, in light of their own present, past information and encounters. Constructivism characterizes a method of conceptualising our comprehension of how learning happens. Socio-constructivism, as Termos (2012:46) posits, has essential spotlight on how learners build their own significance from new data: they interface with the real world and with different learners who bring alternate points of view. Constructivism emphasizes a functioning

learning condition that joins learners learner-centred, issue-based learning, assignment-based learning and request- based learning. All these forms of learning should, ideally, involve certifiable situations in which learners are effectively occupied with basic reasoning exercises: for example, use of online mathematics games.

A constructivist is interested in knowing how the learner is endeavoring to develop meaning. With the aid of online mathematics games, the learner can decipher and grow more familiar with abstract concepts. This familiarity with difficult terms occurs because, the constructivist believes that, information is built by the learner and the learner builds up his/her own comprehension through practice. The constructivist point of view on learning, encapsulated in CAPS, expect that ideas are shaped by individual experience: the learner does not latently assimilate information. The learner is a functioning member in the development of his own insight since information emerges from a cooperation between a learner`s current thoughts and new thoughts. New thoughts are deciphered and comprehended in the light of the learner`s own present information. An individual sees the world through the perspective ("glasses") of his current information and every individual sees the world in an unexpected way.

The constructivist accepts that we see what we comprehend. Applied information can therefore not be shifted conveniently and whole from one learner to another – each learner should fundamentally develop his/her own conceptual information. By playing online games, learners are in a position to construct their own conceptual knowledge. The main part of the time is spent making a difference on learners to gain their own insights, learning with understanding. Exercises and errands are introduced to furnish learners with experience that give chances to new understanding.

Individuals build their own comprehension and information on the world, by encountering certain phenomena and reflecting upon those encounters. Socio-constructivism depends on the conviction that learners learn best when they gain information through investigation and dynamic learning. Hands-on materials are utilized rather than schoolbooks, and learners are urged to ponder and clarify their thinking as opposed to remembering and presenting realities. New knowledge is

linked to prior knowledge, so that mental representations are subjective (Phillips, 2000:8). Knowledge is inseparable from practice. By playing online mathematics games, learners are in a stronger position to grasp algebraic concepts. Phillips (2000:7) defines the following traits of socio-constructivism:

- It helps connect with and inspire learners by making them play a more dynamic job in the educating procedure;
- It uses intelligent instructing techniques to make important settings that help learners;
- Built information based upon their experience; playing online mathematics games facilitates that construction.
- It promotes critical thinking, high order thinking abilities and community work;
- Learners will not be passive participants but active participants.

Socio-constructivism favours learning with understanding since they believe in the idea that learners are not empty vessels, they construct their own knowledge through integrated networks, linking of ideas. Socio-constructivism enables learners to comprehend relations on their own terms and at their own pace; they are able to conclude explicit guidelines and techniques from more broad mathematics relations. Relational comprehension leads to learning with understanding. Social constructivists believe that information is socially developed in a procedure that prompt the development of arranged shared implications (Simon, 2000:220). This process requires teachers, learners and pedagogy specialists to define knowledge. Is knowledge an established body of facts or a mediated sense of the world that resides in the individual? Mediated or shared meanings can be accessed by community members or learners in the mathematics classroom without clarification and defense and can be utilized in the development of progressively modern thoughts. Social constructivists respect all individuals as equal role-players in the making of meaning or construction of knowledge. Through interaction, role-players challenge each other's developments in manners that encourage the development of progressively shared and powerful information (Beswick, 2005:5).

In Chapter 2, I attempted to provide a broad overview of online Mathematics games and their contribution to teaching Algebra in a Grade 8 class. This chapter first, sought to provide a broad definition of online Mathematics games within the context

of educational institutions such as a school. In addition, the chapter focused upon dominant discourses and debates, research around online Mathematics games and their relevant underpinning. In the following section the focus is on structure of the research, research paradigm, and methodology and data collection instruments. Other aspects to be discussed include the procedures followed in selecting of participants, ethical considerations, issues of validity and procedures for analysis of data.

Chapter 3: Research Design and Methodology

3.1 Introduction

In Chapter 2 I discussed the theoretical framework which underpins this study, and I reviewed related literature. The literature dealt primarily with the utilisation of online mathematics games in the mathematics classroom. Research is a procedure of creating logical information in a specific field of study using target strategies and techniques (Kruger & Mitchel, 2005:2). Regardless of the sort of exploration field, there are always underlying philosophical expectations about what comprises legitimate investigation and which strategies are most suitable for generating and developing information that the researcher anticipates may be found. It is of the most extreme significance that any researcher ought to comprehend these philosophical suppositions before undertaking any form of research. The main aim of Chapter 3 was to (i) describe the research design, (ii) explain the research methodology, and methods used for information assortment and information investigation, so as to address the research questions, this chapter discusses how information were collected: by means of questionnaires, observations and interviews, ethical issues, data analysis and issues of validity. Learner knowledge is complex by nature and difficult to capture using a single instrument. I, therefore, have chosen to draw upon multiple data sources “to investigate the research questions from various angles and perspectives” (Christensen and Prout, 2002:147).

3.2. Research Design

This is a qualitative approach set within an interpretive paradigm, with a case study design. Chenail (2010:190) describes subjective research as a way of explaining and understanding the implication that people or gatherings attribute to a specific social or human issue. Qualitative study is in itself different from other types of research because, as Lincoln (2012:4) elucidates, qualitative research consists of rehearses that transform the world into a progression of signs; including field notes, interviews, discussions, photos, accounts and memoranda. Subjective exploration involves a lot of strategies that rely upon information gathered through language: it depends upon phonetic, instead of numeric, information (Elliott &Timulak, 2005:147).

Qualitative study comprises a comprehensive study of groups of people so that the researcher can define commonalities and differences in the data, in order to discern patterns in the information which leads to a sustainable hypothesis for the investigation as a whole (Frederick, 2013:1). Subjective examination discoveries are clear as opposed to prescient (QRCA, 2003:1), including clarifications, verbalized thoughts and observed behavior. One of the most significant aspects of qualitative study is that it is by large relies on inductive thinking procedures to decipher and structure the implications that can be gotten from information. Inductive thinking is the procedure by which the researcher generates ideas or themes from the data collected (Thorne, 2000:68).

3.2.1. Characteristics of qualitative research

Each type of research has its own features. Cresswell (2014:186) defines the following characteristics of qualitative research as that, “(i) The first characteristic is that qualitative research is often conducted in the field, allowing direct interaction with the individual subject being studied in context; (ii) Researchers collect data themselves by examining documents, observing behavior or interviewing participants; (iii) The other characteristics are that multiple sources of data are preferred over a single source; this variety of sources requires the researcher to review all data, make sense of it and organize it into categories or themes that cut across all sources. Researchers often build their patterns, categories and themes from the bottom up by means of inductive analysis”.

3.2.2. Interpretivism

According to Adendorff (2007:50) an interpretive approach is particularly appropriate for, “research that includes a socially important activity, which is examined through the direct point by point perception of people in characteristic settings; so as to show understanding and translations of how those observed make and keep up their social universes. An interpretive paradigm is concerned with (i) how individuals experience and understand the world and (ii) habits by which they connect and the conditions or settings where those conditions happen”. Interpretive research shows that people are creative in their actions and that they make meanings through their activities

(Ahmed, 2008).I employed an interpretative paradigm to gain an empathetic understanding of why learners fail to understand algebra (Cohen, Manion & Morrison, 2011:116).Blaikie (2000:115) states that an interpretive paradigm regards the selected subjects as primary sources of data. An interpretive paradigm is concerned with the individual because it seeks to know how each individual perceives of the world. Cohen, Manion and Morrison (2011:116) states:

> An interpretive paradigm rests in part on a subjective, interaction's, socially constructed ontology and on an epistemology that recognizes multiple realities, agentic behaviours and the importance of understanding a situation seen through the eyes of participants

The notion that an interpretive worldview considers its subjects as primary sources of data is supported by the Institute of Public and International Affairs (2009:1) which asserts:

> Interpretive methodologies position the meaning making of human actors at the centre of scientific explanation. Interpretive research focuses on analytically disclosing those meaning making practices, while showing how those practices configure to generate observable outcomes.

Angen (2000:378) explains that interpretive methodologies depend intensely upon naturalistic techniques: interviewing, perceptions and investigation of existing writings. Careful attention to these naturalistic techniques ensures that a valid and in-depth conversation takes place between researcher and participants; so as to build an important reality through close collaboration. The interpretivist believes that the truth is built by social entertainers and the discernments of the individuals (Wahyuni, 2012:72). An interpretive paradigm attempts to comprehend a chosen situation by interpreting the meanings assigned to phenomena by participants. An interpretive researcher is (i) inspired by the implying that individuals credit to wonders and (ii) requires a detailed and careful investigation of social circumstances and (iii) requires direct information (Willis, Daly & Kealy, 2007). In an interpretive paradigm, researchers interpret what is seen, heard and understood. An interpretive paradigm is established on the conviction that the truth is fluid and socially built.

3.2.3. Case Study

Yin (2009:18) characterizes a contextual analysis strategy as an experimental enquiry that examines a contemporary marvel inside its genuine setting; where the limits between the phenomenon and setting are not unmistakably characterized and in which numerous sources of data collection are deployed. Case studies, according to de Vaus (2001:220) are by definition pluralistic, descriptive and heuristic; indicating that a contextual analysis centres upon a particular event and has the potential to provide meaningful insight into how individuals confront problems through a holistic view of the situation. I used a case study design because of the following hallmarks which give a sequential account of occasions pertinent to the case.

A contextual investigation is concerned about introducing a rich and striking depiction of occasions identified with the case. A case study:

(i) can be attempted by a solitary specialist without requiring a full exploration group;
(ii) the outcomes are effortlessly comprehended by a wide crowd as they are much of the time written in regular, non-proficient language;
(iii) mixes a portrayal of occasions with an investigation of them;
(iv) gives an ordered account of occasions;
(v) permits researchers to hold the comprehensive and important qualities of genuine occasions, and
(vi) focuses on individual participants and looks to comprehend their view of occasions and the researcher is necessarily associated with the case (Cohen et al., 2011:182).

Although a case study design has some challenges such as determining the scope of the research, results may not be generalizable: they are inclined to eyewitness inclination, in spite of endeavours made to address reflexivity and the way in which a case illustrates an issue (Cohen et al., 2011:184). As a researcher, I was intensely mindful of these challenges, hence an endeavour to counter these challenges by minimising overly subjective interpretations**.** A case study was used because it describes in depth the experience of participants when learning via online

mathematics games. A case study allows room for direct-observation and interaction between participants and researcher (Creswell, 2013).

3.3. Research Methodology

According to Rajasekar (2006:5) research methodology comprises ways by which researchers approach their work of depicting, clarifying and foreseeing marvels. Research system is a way to find solutions to certain carefully formulated research questions. Site selection and sample size are discussed in this section.

3.3.1. Site Selection

The research occurred at a secondary school in the Metro North Education district in Cape Town, in the Western Cape. The researcher conveniently chose this site because it was easily accessible; the school climate was conducive to learning which made it easy to engage learners. The school has limited technological resources: mathematics learners are not readily exposed to technological aids during lessons. The reason for using convenience sampling links Wegner`s (2007:214) statement that convenience sampling is ideal since sampling units are selected to suit the convenience of the researcher. This situation of limited technological resources helped to make the contribution of online mathematics games plain during Algebra lessons. I chose one school so that I could have an in-depth case study with minimum time constraints and problems of accessibility. The school accommodates all learners from different social backgrounds. The school employs English as the mechanism of guidance. The researcher chose Grade 8 class because that was the foundational class for high school mathematics.

3.3.2. Participant Selection

A group of 30 Grade 8 learners and the Mathematics teacher were participants in this study. The class was large enough for the researcher to have a detailed comprehension of the contribution of online mathematics games to gain a better understanding of Algebra in Grade 8. The projected sample consisted of **31** participants as shown below:

(i) Grade 8 Mathematics learners N = 30
(ii) Grade 8 Mathematics teachers N = 1 (Sample size: N = 31)

3.4. Data Collection

In this research project, three research methods, namely observations, questionnaires and interviews, were used.

3.4.1. Observations

Observations were conducted within the parameters of qualitative research. The aim of using observations was to determine how learners use online mathematics games and whether online mathematics games contribute meaningfully to a better understanding of algebra. Observations allowed the researcher to gauge how learners were playing online mathematics games during the lesson. According to Creswell (2014:190), “qualitative observation indicates that the researcher takes field notes on the behaviour and activities of individuals at the research site and records observations”. William (2006:286) notes that:

> Observation is the systematic noting and recording of events, behaviours in the social setting chosen for study. The goal of observation is to immerse the researcher in the setting, so he or she can see, hears, feel, experience participants’ daily life.

According to the observational protocol, I completed a form (Appendix A) when learners were playing online mathematics games. I observed the lessons to determine whether and to what extent online mathematics games improved learners` understanding of Algebra. The interaction and enthusiasm of learners as they worked during the lesson were observed.

3.4.1.1. Advantages of observations

Observations were conducted because they provide the researcher with concrete evidence of events as they unfold. The researcher can record data as it happens, strange perspectives can be seen during observations and there is no need for the researcher to fear the sort of exaggeration which can occur with self-reporting (Basit, 2010:120).Patton and Cochran (2002:22) assert that observational information is

important in bridging errors between what individuals state and what they really do and may enable the researcher to reveal conduct of which the members themselves might know.

Jacobson (2009:5) postulates some of the reasons for observing participants as being that:

> Data are collected where and when an event or activity is occurring. The observer sees directly what participants do rather than relying upon what they say they do. Classroom observations provide the researcher with first-hand experience of participants' activity by recording information as it occurs as well as by taking note of unusual aspects.

3.4.1.2. Disadvantages of observations

The drawbacks of observations are that the anonymity of participants is not guaranteed, and the presence of the observer might affect learners` behaviour: respondents might become withdrawn, passive and exhibit no interest at all. Participants may consider the researcher to be intrusive. The researcher may not be adept at interviewing participants and might lack the subtle skills needed for observation, which may result in unreliable conclusions (Finn & Jacobson, 2008:56). The researcher may counter these disadvantages by explaining the significance of the research to participants and by adhering precisely to confidentiality protocols.

3.4.2. Questionnaire

A survey is an instrument utilized for gathering information which perpetually includes requesting that a given subject react to a lot of oral or composed inquiries (Creswell, 2014).A survey was submitted to participants to gauge their perspectives on how they viewed the use of online mathematics games when doing Algebra. A structured questionnaire with open ended and closed questions was developed in line with the research topic (Appendix B).

3.4.2.1. Advantages and Disadvantages of a questionnaire

According to Vuuren and Maree (2002:281), the use of questionnaires is economical, ensures anonymity and allows room for uniform procedures. Questionnaires have

drawbacks: participants must be literate, and questionnaires do not always permit the researcher the chance to probe and clarify some of the implications of the questions posed.

3.4.3. Interviews

Interviews were used by the researcher to gain feedback on contribution of online mathematics games to learners` understanding of Algebra. Fraenkel (2012:451) articulates that interviewing is a way of (i) assessing what people think through their speech and (ii) capturing direct quotations from participants. The researcher interviewed learners individually to (i) estimate their views on online mathematics games, (ii) enquire from them how they used online mathematics games and (iii) how the online mathematics games helped them. The answers were recorded. The interview questions for the learners were developed based upon the learners' experience during lessons. Six learners were chosen randomly from the participants to take part in the interviews (Creswell, 2014). The prescribed interview protocol (Appendix C) was used when carrying out the interviews.

3.4.3.1. Benefits of interviews

Interviews (i) allow room for the researcher to ask probing questions where necessary and (ii) evince detailed responses. An interview can possibly be brisk and simple to utilize; it has an organized condition that assists with decreasing anxiety or dread. Interviews can be conducted face-to-face; allowing the researcher to gather people`s thoughts, feelings, qualities and convictions about a certain theme. The researcher can guarantee that (i) questions are completely comprehended and that (ii) an agent test is conceivable and that (iii) outcomes can be utilized to offer expressions (Mouton, 2001:106).

3.4.3.2. Drawbacks of interviews

It tends to be hard to acquire solid information on perspectives, suppositions and qualities from standard interviews, except if approved polls are utilized. The questioner needs to submit to the settled upon questions, albeit fascinating lines of enquiry may develop in a meeting. The analyst may create predisposition by the correspondence style used to convey questions or potential reactions. There is

restricted open door for interviewees to go past the set inquiries except if incited to do by the researcher. Meetings can be tedious for both researcher and interviewee. A restricted measure of information gathered may not precisely mirror the perspectives on the more extensive populace. Interviews may be difficult to organize because a reasonable spot and time between researcher and interviewee are not always easy to fix (Mouton, 2001:106).

Although interviews are time-consuming and costly, this was not a deterrent to the researcher since there was time enough to gather data and a suitable venue was found at which to conduct all the interviews.

3.5. Data Analysis

Creswell (2014:186) characterizes information examination as a procedure for obtaining and converting data into information which are pertinent and valid, allowing users to make decisions. In this research, inductive data analysis was used. Subjective information was gathered in different structures: by means of field observation and interviews to accomplish triangulation of information. The researcher in this way led an investigation of subjects so as to catch the estimation of web-based learning through the voices of the individuals who took an interest straightforwardly in its execution. I scrutinized the data for themes, concepts and propositions, coding the data and understanding the data in the context in which it was collected (Creswell, 2014:186). I worked back and forth between the themes and database until I established a comprehensive set of themes according to the prescripts set out for inductive data analysis (Mouton, 2001:109). The diagram below shows how the data were validated.

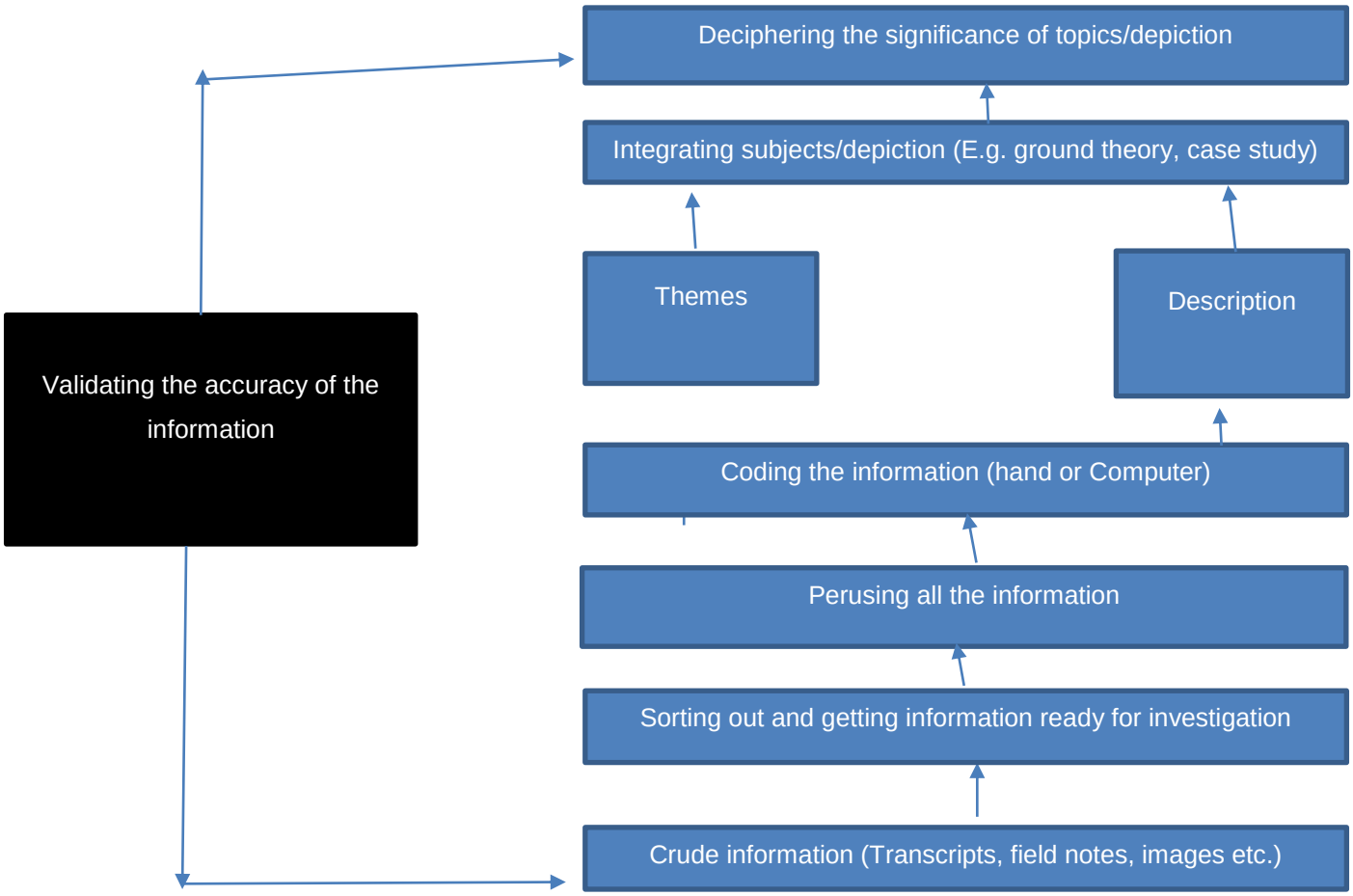


Figure 12. Validation of information Creswell (2009:185)

I adopted a progressive methodology as shown above by working from the base to the top. I used the eight steps in the above figure because they engaged the researcher in an efficient procedure of breaking down literary information (Creswell, 2009:186). I followed the procedure below:

(i) check raw data for anomalies and quality;
(ii) focus the analysis (review the purpose of the research);
(iii) identify patterns within and between categories;
(iv) sort and assemble all data by themes emanating from research and interpret what has been learned.

3.6. Validity

For ensuring the trustworthiness of this study, appropriate methods were used that included member checking, triangulation and external audit (peer reviews). According to Terre Blanche and Durrkein (2006:147), “validity is the degree to which

a measure does what it is intended to do". For that reason, different methods for ensuring validity are discussed in detail below.

3.6.1. Methods of ensuring validity

3.6.1.1. Participant inspection

Patton and Cochran (2002:26) hold that, "member checking is a validity strategy that involves feeding findings of the analysis back to participants and assessing how far they consider them to reflect the issues from their perspective". In this regard, I used recordings taken during interviews and observation sheets; and then transcribed the data. Care was taken not to lose data by having a backup system, for instance, having extra copies and saving on a removable disk.

After completing each classroom observation, a preliminary data review with participants was conducted, before data were transferred or transcribed and interpreted for further analysis by preparing a narrative account of each classroom observation. In addition, after each lesson observation and interview with participants, I compared and contrasted their responses with what actually took place in the classroom, to make the research feasible, viable and trustworthy. Validity was ensured through direct contact at the purpose of the meeting with participants: information was checked for exactness and significance when gathered. Careful attention was paid to all details while collecting data and analyzing it to ensure the trustworthiness of the research process. Moreover, I asked teachers and learners to assess the findings, interpretation, discussions and conclusions to pave the way for corrections.

3.6.1.2. Triangulation

Triangulation was applied to validate data through the use of various techniques for collecting data. Basit (2010:67) characterizes triangulation as a procedure which is utilized to set up simultaneous legitimacy in research by taking a gander at a similar issue from alternate points of view. Denzin (2006:91) contends that triangulation includes more than one strategy to accumulate information, for example, interviews, perceptions, surveys and reports. Fraenkel (2012:517) states that when an end is bolstered by information gathered from various instruments, its legitimacy is

improved. Using multiple data collection methods increased the validity of the findings which resulted in justification and consensus of the data collected.

3.6.1.3. External audit

An external audit was achieved by obtaining individuals outside of the investigation to survey and assess the report. I asked several outside experts to audit and cross-check the data collected as well as to read and critique the findings before compilation. I enlisted an outer evaluator to audit the whole undertaking. I made use of the assistance offered by my supervisor, resulting in the validity of the study. Experts such as editors and other academics assessed the quality of the research.

3.6.1.4. Peer review

As part of the process for quality assurance, I asked colleagues to review the findings, interpretations, discussions and conclusions. I discussed with peers their knowledge and provided suggestions about insights into the findings.

3.7. The Researcher`s Role

I was involved in working with the teacher to facilitate algebra lessons, centering upon: (i) online mathematics games, (ii) observing the engagement of learners during the lessons and (iii) interviewing the learners. As indicated by Creswell (2009:177) as the researcher, I included explanations about past encounters that give foundation information through which members could all the more likely comprehend the point, the setting and the researcher`s understanding of the marvels.

3.8. Ethical Considerations

Moral apprehensions are the, “concerns and dilemmas that arise over the proper way to execute research, more specifically not to create harmful conditions for the subjects of inquiry, humans, in the research process” (Schurink, 2005). The specialist clarified that taking an interest in the examination was intentional and that if for reasons unknown any member wished to pull back from it, s/he reserved the privilege to do as such whenever. Williams (2007:72) agrees that:

Research participants have full autonomy and confidentiality, they

have the right to understand the research so that they can decide whether to participate in the research or not.

Learners were issued with consent forms to be signed by their parents/guardians. Learners who were involved were told that the information gathered was confidential and that no-one would know their identities, except the researcher. The names of the subjects were detached from all information assortment structures. The researcher allocated pseudonyms. The researcher applied for consent to direct the study from the Western Cape Education Department, Cape Peninsula University of Technology, Principal (Appendix D) and from parents (Appendix E) (Creswell, 2013:248).

This section has depicted the methodology received and purposively adapted to the research study concerning the use of online Mathematics games in classroom practice. I have focused on the elements and structure of design and methodology used in this research. I have explained in detailed why I chose a qualitative approach in which the choice of method was a case study. Multiple data sources employed in this study were explained in depth. I have elucidated the weaknesses, qualities and different restrictions of a contextual investigation structure. I have outlined my job as a member eyewitness and indicated how I conformed to the ethical considerations of valid research.

The next section, Chapter 4, deals with the examination and translation of information. The chapter presents an understanding and thorough examination of the information. It describes how data were translated, transcribed, coded and categorized in the process of looking for meaning, by making comparisons and identifying contrasts. In addition, Chapter 4 attempts to make importance of the information gathered.

Chapter 4: Data analysis and discussion of findings

4.1 Introduction

In the preceding section, I examined the research paradigm, research design and data collection methods. In addition, I discussed ethical issues and validity linked to data collection and analysis processes and related to answering the study questions.

The chapter deals with data collection and analysis procedures and presents a discussion of the findings, in order to answer the research question: How do online mathematics games contribute to algebra understanding in grade 8? The main reason for the study was to clarify and pick up knowledge into the matter of whether online mathematics games contribute to a better understanding of algebra in Grade 8 mathematics through intensive production of narrative data. The data gathered from classroom observations, questionnaires and interviews are presented and discussed in detail.

The analysed data were gathered through classroom questionnaires, observations and semi-structured, face-to-face interviews. More information about data collection was provided in Chapter 3. Pseudonyms were used for learner participants. Participating learners are referred to as L1, L2, L3, L4, L5, and L30. Pseudonyms are used to protect the identities of and are in line with the confidentiality requirements of CPUT Research Ethics. The information examination process began with deciphering information from observations, interviews and video recordings. The process of transcribing data was exhaustive and took many hours to complete a thorough examination of all the narrative data. From the findings, it was clear that encouraging use of certain online mathematics games in certain contexts does improve learners` knowledge of algebra.

4.2.1. Procedure for analyzing data

The study was conducted over 4 weeks in August 2018. The principal and teacher concerned were informed of the study and permission sought. The parents of the participating learners were requested to sign parent consent forms. Online mathematics games were used to supplement standard instruction in class. No extra

time was accommodated playing the online mathematics games. Online mathematics games were played during standard class periods time of 40 minutes which amounted to 24 periods over 4 weeks.

The process of analyzing data began with deciphering information from interviews with learners. In the wake of interpreting the discussions, I came back to the recordings to contrast the records and what really unfolded during classroom observations and interviews. That comparison involved replaying the recordings many times to capture as much data as possible. The process of recording information was exhaustive, and it took many hours to examine all the narrative data (Creswell, 2013:248). I meticulously watched learners` behaviours, spoken and non-verbal outward appearances when they collaborate with the online mathematics games, their peers and the external environment. The recorded data was then send to external auditors and the supervisor to check and read the data collected authenticate the validity of the results.

4.2.2. Data collection strategies

Semi-structured interviews and classroom observation field-notes were deciphered, dissected and coded meticulously. The information was arranged by members` reactions during the meetings and class observations. These reactions were perused and re-read to discern meanings about the contribution of online mathematics games on Algebra understanding in Grade 8. The accompanying methods were followed:

Information were gathered and sorted out for examination purposes through record of meetings and portrayal of classroom perceptions:

- The transcribed data were read and re-read to discover patterns of meaning in the data. Re-reading data was done to make sure that the important information was captured for further analysis; and
- The transcribed data were coded into different categories to identify relations and differences in the data collected for interpretation. Data dissected in various phases: the first phase was the dissection of learners' interview responses and the next phase involved analysis of classroom observations. The following were some of the themes extracted during transcribing of data:

Learners paying attention, Alert, active participants, remove distractions, feel comfortable seeking help or asking questions, understanding rules of the game, encourage and extend learners communication, engaging, positive achievement, able to link Algebra symbols with symbols and patterns in the game, comfortable playing games on their own, feedback given, fun and interesting, helps to think and understand concepts, increase concentration levels, hardworking, Gives one a challenge and competition, motivating, makes learning easier, distractions, makes the subject interesting, highly comfortable, one will be focused, get most of the questions correct, mind blowing, rewarded with points each time you succeed, give detailed descriptions, children gets bored, app that helps understand Mathematics, Give all your attention, difficult to get to the next level, practice.

I then grouped the above comments or responses into different categories. The categories were mastery, stimulation and impediments. This categorization appears in the table below.

Table 4. 1. Categories of transcribed themes

Mastery	Stimulation	Impediments
➢ *Practice* ➢ *App helps to understand Mathematics* ➢ *Active participants* ➢ *Increase concentration* ➢ *Give all your attention* ➢ *Give detailed descriptions* ➢ *Helps to think and understand concepts* ➢ *Get most of the questions correct* ➢ *Makes learning easier* ➢ *Hardworking* ➢ *Understand rules of the game* ➢ *Feel comfortable seeking help or asking questions*	➢ *Give all your attention* ➢ *Rewarded with points* ➢ *Mind blowing* ➢ *Highly comfortable* ➢ *Makes the subject interesting* ➢ *Gives one a challenge and competition* ➢ *Fun and interesting* ➢ *Feedback given* ➢ *Encourage and extend learners communication*	➢ *Difficult to get to the next level* ➢ *Children gets bored* ➢ *Distractions*

4.3. Analysis of questionnaires

Questionnaires were completed by all 30 participants in the research project. The questionnaires became the lens through which to measure and understand how participants viewed their own development after using online mathematics games (Schmidt, Baran, Thompson, Koehler, Mishra & Shin, 2009:130).The response rate of participants to self-completion questionnaires which were administered are demonstrated as follows.

Table 4. 2: Reaction rate

n=30

Participants	Questions Administered	Questions Answered	Response rate as percentage
L1	9	9	100%
L2	9	9	100%
L3	9	9	100%
L4	9	9	100%
L5	9	8	89%
L6	9	9	100%
L7	9	9	100%
L8	9	9	100%
L9	9	9	100%
L10	9	9	100%
L11	9	9	100%
L12	9	5	56%
L13	9	9	100%

L14	9	9	100%
L15	9	9	100%
L16	9	9	100%
L17	9	9	100%
L18	9	9	100%
L19	9	9	100%
L20	9	9	100%
L21	9	9	100%
L22	9	9	100%
L23	9	9	100%
L24	9	7	78%
L25	9	9	100%
L26	9	9	100%
L27	9	9	100%
L28	9	9	100%
L29	9	9	100%
L30	9	9	100%

Source: Primary data

The results in Table 4.2 indicate that 90% of learners had the highest response rate (100%) while only 10% of the learners had a response rate of less than 100%. The responses to the questionnaires were high enough to enable the researcher to draw meaningful conclusions regarding the research findings.

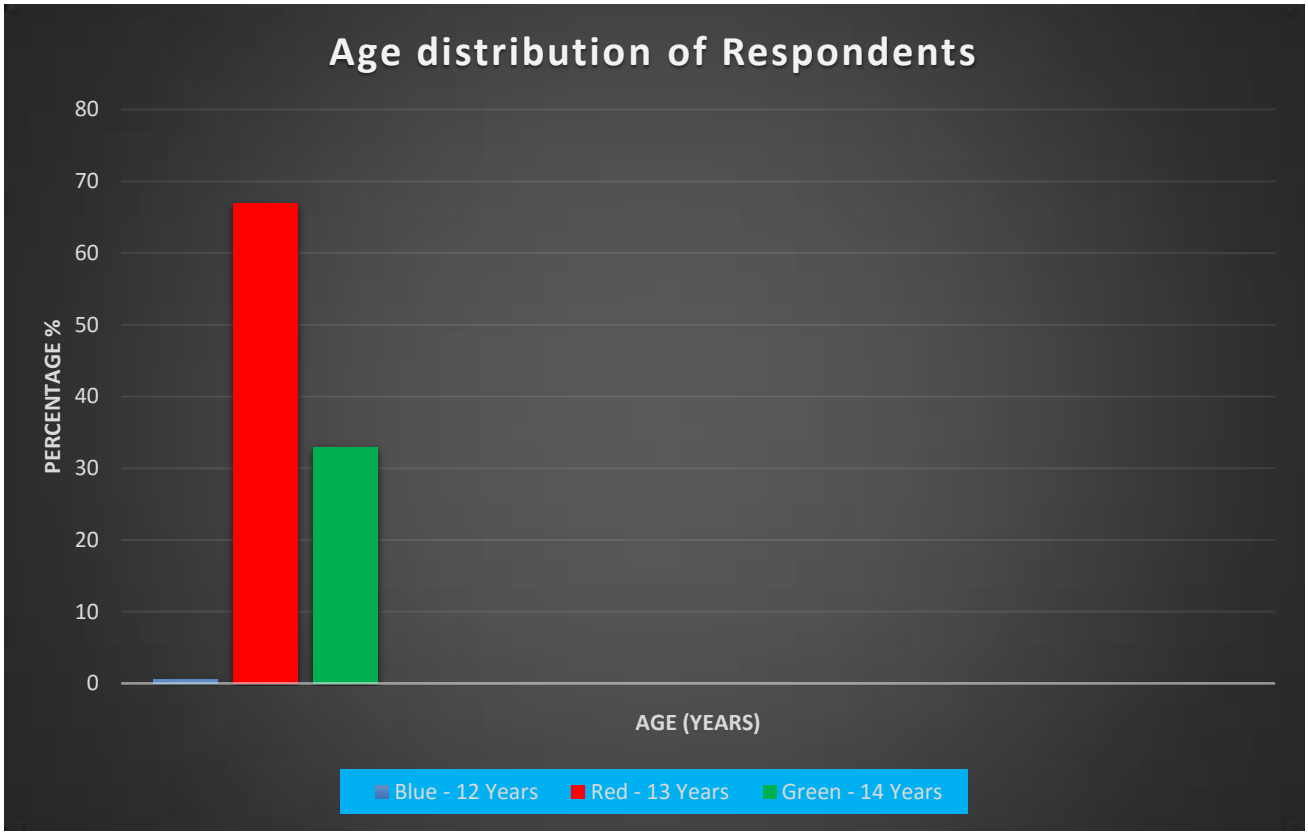


Figure 13. Age distribution of participants

(Source: Primary data)

Results in figure 4.2 above show that most of the respondents, 67%, were aged 13 years and 33% aged 14 years.

Table 4. 2: The rate circulation of how respondents perceived the contribution of online mathematics games to an understanding of algebra in Grade 8 Mathematics.

Statement	Number of participants and percentage (%) response			
	YES		NO	
	Nu	%	Nu	%
Do you think learning without online mathematics games is boring?	29	97	1	3
Do you feel comfortable playing online mathematics games?	25	83	5	17
Do online mathematics games contribute in understanding abstract concepts?	20	67	10	33
Do you feel the use of online mathematics games helped you in understanding algebra better?	20	67	10	33
Online mathematics games increase concentration levels of learners during lessons?	24	80	6	20
Do online mathematics games arouse your interest in class?	24	80	6	20
Is algebra difficult without being taught using online mathematics games?	24	80	6	20

Key:

Nu – number of respondents

Y - Yes

N - No

The discoveries in Table 4.3 uncovered the accompanying discernments concerning the contribution of online mathematics games to better understanding algebra in grade 8 Mathematics by participant learners.

Statement 1

Do you think learning without online mathematics games is boring?

The results in statement 1 revealed that the majority (97%) of participants agreed that learning without online mathematics games was boring while only (3%) disagree with the statement.

Statement 2

Do you feel comfortable playing online mathematics games?

In statement 2 the results revealed that most of the participants (83%) agreed that they felt comfortable playing online mathematics games while (17%) disagreed with the statement.

Statement 3

Do online mathematics games contribute to an understanding of abstract concepts?

Findings in statement 3 uncovered that most of the members (67%) agreed that online mathematics games contributed in understanding abstract concepts while (17%) disagreed with the statement

Statement 4

Do you feel the use of online mathematics games helped you in understanding algebra better?

In addition, the results in statement 4 revealed that most of the participants (67%) felt that the utilization of online mathematics games helped them in understanding algebra better while (17%) disagreed with the statement.

Statement 5

Do online mathematics games increase concentration levels of learners during lessons?

Furthermore, findings in statement 5 uncovered that most of the members (80%) agreed that online mathematics games increased concentration levels of learners during lessons while (20%) disagreed with the statement.

Statement 6

Do online mathematics games arouse your interest in class?

The findings in statement 6 revealed that the majority of participants (80%) agreed that online mathematics games aroused their interest during lessons while (20%) disagreed with the statement.

Statement 7

Is algebra difficult without being taught online mathematics games?

Findings concerning statement 7 uncovered that most of the participants (80%) agreed that algebra was difficult when taught without online mathematics games while (20%) disagreed with the statement.

Questionnaire

Thank you for consenting to answering this questionnaire. The purpose of this questionnaire is to find out if online mathematics games help learners in understanding and solving algebraic questions. Your co-operation in this regard and responses are greatly appreciated. Your responses will be completely anonymous.

i. Please answer all the questions.

1. What do you understand by online mathematics games?

Games that you play which involve mathematics

2. Do you think learning without online mathematics without games is boring?

Yes [X] No [ ] Explain your answer.

Online games makes maths fun and interesting

3. Do you feel comfortable playing online mathematics games?

Yes [X] No [ ] Explain your answer

It helps me think and understand concepts better

4. Do online mathematics games contribute in understanding abstract concepts?

Yes [X] No [ ] Explain your answer

Pay more attention which leads to one wanting to know more

5. Do you feel the use of online mathematics games helped you in understanding algebra better?

Yes [X] No [ ] Explain your answer

By finishing each level, I was able to know most of the concepts.

6. Online mathematics games increase concentration levels of learners during lessons?

Yes [X] No [ ] Explain your answer

When you play a game you concentrate more because it is interesting

7. Do online mathematics games arouse your interest in class?

Yes [X] No [ ] Explain your answer

It is fun and interesting. It makes me want to do Maths more

8. What do you like or dislike most about online mathematics games?

It gives one a challenge and competition but one can be stuck on one level if you do not know how to play.

9. Is algebra difficult without being taught using online mathematics games?

Yes [X] No [ ] Explain your answer

Learning whilst having fun makes everything look easier

Questionnaire

Thank you for consenting to answering this questionnaire. The purpose of this questionnaire is to find out if online mathematics games help learners in understanding and solving algebraic questions. Your co-operation in this regard and responses are greatly appreciated. Your responses will be completely anonymous.

i. Please answer all the questions.

1. What do you understand by online mathematics games?

Games played in maths to create a better understanding of what u learn

2. Do you think learning without online mathematics without games is boring?

Yes [X] No [ ] Explain your answer.

because some people might learn better in solving a fun way

3. Do you feel comfortable playing online mathematics games?

Yes [X] No [ ] Explain your answer

it is easier and fun because it teaches your brain and is a fun game

4. Do online mathematics games contribute in understanding abstract concepts?

Yes [X] No [ ] Explain your answer

it will teach you more about how to do it and it being fun too.

5. Do you feel the use of online mathematics games helped you in understanding algebra better?

Yes [ ] No [X] Explain your answer

I find the way of normal learning in algebra is more understandable.

6. Online mathematics games increase concentration levels of learners during lessons?

Yes [X] No [ ] Explain your answer

games might be something you do in your free time. and you concentrate more.

7. Do online mathematics games arouse your interest in class?

Yes [ ] No [X] Explain your answer

games makes me distracted and if I play mathematics games a lot it makes me sidetracked.

8. What do you like or dislike most about online mathematics games?

No the game might not always be understandable.

9. Is algebra difficult without being taught using online mathematics games?

Yes [X] No [ ] Explain your answer

it doesn't make you learn anything it just confuses you if you dont teach how to do it

Questionnaire

Thank you for consenting to answering this questionnaire. The purpose of this questionnaire is to find out if online mathematics games help learners in understanding and solving algebraic questions. Your co-operation in this regard and responses are greatly appreciated. Your responses will be completely anonymous.

i. Please answer all the questions.

1. What do you understand by online mathematics games?

Games one can play on computer or smart phone

2. Do you think learning without online mathematics without games is boring?

Yes [X] No [ ] Explain your answer.

Games makes the subject interesting

3. Do you feel comfortable playing online mathematics games?

Yes [X] No [ ] Explain your answer

I feel highly comfortable for I am used to playing games

4. Do online mathematics games contribute in understanding abstract concepts?

Yes [X] No [ ] Explain your answer

One will be focused so it makes understanding a lot easier

5. Do you feel the use of online mathematics games helped you in understanding algebra better?

Yes [X] No [ ] Explain your answer

I was able to get most of the questions correct.

6. Online mathematics games increase concentration levels of learners during lessons?

Yes [X] No [ ] Explain your answer

high concentration levels will be evident.

7. Do online mathematics games arouse your interest in class?

Yes [X] No [ ] Explain your answer

Absolutely

8. What do you like or dislike most about online mathematics games?

I like online mathematics games because it uses stuff we use on a daily basis in our lives.

9. Is algebra difficult without being taught using online mathematics games?

Yes [X] No [ ] Explain your answer

Since you will be enjoying playing the game you won't even realise how difficult the subject is since it will be fun and interesting.

Questionnaire

Thank you for consenting to answering this questionnaire. The purpose of this questionnaire is to find out if online mathematics games help learners in understanding and solving algebraic questions. Your co-operation in this regard and responses are greatly appreciated. Your responses will be completely anonymous.

i. Please answer all the questions.

1. What do you understand by online mathematics games?

It is a mathematical app that helps learners understand maths

2. Do you think learning without online mathematics without games is boring?

Yes ☐ No ☒ Explain your answer.

It is funny if you are interested in algebra

3. Do you feel comfortable playing online mathematics games?

Yes ☒ No ☐ Explain your answer

I like playing online games because it helps me understand algebra

4. Do online mathematics games contribute in understanding abstract concepts?

Yes ☒ No ☐ Explain your answer

When playing a game ~~it's~~ you give all of your attention to the game

5. Do you feel the use of online mathematics games helped you in understanding algebra better?

Yes ☒ No ☐ Explain your answer

Playing these games it's like solving an algebraic equation

6. Online mathematics games increase concentration levels of learners during lessons?

Yes ☒ No ☐ Explain your answer

Because I remained focused most of the time

7. Do online mathematics games arouse your interest in class?

Yes ☒ No ☐ Explain your answer

It raised my concentration levels

8. What do you like or dislike most about online mathematics games?

It is difficult to get to the next level if you don't understand the game

9. Is algebra difficult without being taught using online mathematics games?

Yes ☒ No ☐ Explain your answer

because it will take a very long time for you to understand the concept of algebra

Questionnaire

Thank you for consenting to answering this questionnaire. The purpose of this questionnaire is to find out if online mathematics games help learners in understanding and solving algebraic questions. Your co-operation in this regard and responses are greatly appreciated. Your responses will be completely anonymous.

i. Please answer all the questions.

1. What do you understand by online mathematics games?

Games that you play which involve mathematics

2. Do you think learning without online mathematics without games is boring?

Yes ☒ No ☐ Explain your answer.

Online games makes maths fun and interesting

3. Do you feel comfortable playing online mathematics games?

Yes ☒ No ☐ Explain your answer

It helps me think and understand concepts better

4. Do online mathematics games contribute in understanding abstract concepts?

Yes ☒ No ☐ Explain your answer

Pay more attention which leads to one wanting to know more

5. Do you feel the use of online mathematics games helped you in understanding algebra better?

Yes ☒ No ☐ Explain your answer

By finishing each level I was able to know most of the concepts.

6. Online mathematics games increase concentration levels of learners during lessons?

Yes ☒ No ☐ Explain your answer

When you play a game you concentrate more because it is interesting

7. Do online mathematics games arouse your interest in class?

Yes ☒ No ☐ Explain your answer

It is fun and interesting. It makes me want to do Maths more

8. What do you like or dislike most about online mathematics games?

It gives one a challenge and competition but one can be stuck on one level if you do not know how to play.

9. Is algebra difficult without being taught using online mathematics games?

Yes ☒ No ☐ Explain your answer

Learning whilst having fun makes everything look easier

Looking closely at the learners' questionnaire responses, the researcher determined the following reasons for the impacts of online mathematics games:

- The online mathematics games were elective methods of educating and a positive change that removed learners from pencils and paper and drew in them arithmetic exercises.
- The online mathematics games had an empirical nature which permitted learners to collaborate with recognizable conditions in the games and develop their mathematics ideas through finishing game missions.
- The online mathematics games made learners to be keen on learning mathematics. When learners played the online mathematics game, they needed to find out additional information and gave more consideration since they got a kick out of the chance to pass or went past the game missions. One of the learners expressed: It was (the online mathematics games) that made them want to learn mathematics.
- The online mathematics games improved learners' perspective about mathematics. The learners got mindful of the relations among mathematics and reality and their arithmetic fear was lessened.
- The online mathematics games entrenched arithmetic ideas in the minds of learners because they used concepts such as equivalence in game playing.
- Learners accepted that the mathematics games positively affected their mathematics accomplishment and inspiration. The vast majority of the learners reported somewhat positive to very positive impact of the online mathematics games on their achievement and motivation

4.4. Analysis of responses from interviews

I interviewed six learners after using online mathematics games to solve algebra problems. According to Delamont (2012:364) "We interview in order to find out what we do not and cannot know otherwise". The interview questions were flexible so as to urge participants to build up an account around educating with PCs. Each interview took 20 minutes and was sound-recorded and interpreted (Brownlee, Johansson, Walker & Scholes, 2016).

Various themes emerged that indicated how fluid the perspectives and understanding of online mathematics games were among both teachers and learners. I was able to probe more deeply in certain instances to obtain additional information. The main themes identified from the analysis of interviews were:

(i) Learners' beliefs about online mathematics games – In considering online mathematics games as a necessity for learner achievement, participants were all in agreement that online mathematics games enhanced their understanding of algebra.

(ii) Learner motivation – most of the learners agreed that online mathematics games ignited their interest because of the existence of competition and fun (Bragg 2006:220). This view was supported by NCTM (2000:16) who state that learners like to compete, which motivates them to work out the total scores of the players and the difference in scores to determine who the winner is.

4.4.1. Reaction rate for interviews

The reaction rate for interviews is shown below:

Table 4. 3: Percentage of reaction rate for interviews

n=6

Participants	Directed number for interviews	Interviews conducted	Reaction rate (%)
Interviewees	6	6	100

Source: primary data

Table 4.4 shows the number of learners who were able to complete the interview. All six learners completed the interviews. The response rate was high enough to make meaningful conclusions regarding the research findings (Creswell, 2014).

4.4.2. Analysis of interview data concerning the contribution of online mathematics games to understanding algebra in grade 8 mathematics.

The following are questions I asked the participants during interviews. Each participant answered all the questions:

4.4.2.1. Describe what you know about online mathematics games.

4.4.2.2. Do you find it easier to understand Mathematics when taught using online mathematics games?

4.4.2.3. Are you comfortable learning mathematics using online mathematics games? Why/Why not?

4.4.2.4. Do you consider the use of online mathematics games in the mathematics classroom as a necessity for learner achievement in mathematics? Explain how?

4.4.2.5. Are you motivated to use online mathematics games more often to enhance your understanding of algebra?

4.4.2.6. Do you think that your performance was enhanced by the use of online mathematics games? Explain how.

The following are some of the participants` comments during interviews:

Learner 1

"I did not know that equations $5 + x = 4$ *are different from expressions* $A(x + y)$ *but after playing the games and the teachers' reinforcements, I now know that for the first equation "*x*" is an unknown and 4 is the solution and the second expression "*x*" is being used to generalize the pattern".*

Another participant Learner 2 stated that:

I didn't really understand what equivalence was. The Dragon Box really helped me a lot because it simplified the algebraic concepts into a game. Moreover, it was also fun to learn whilst playing. I now understand that both sides of the equal sign have the same value. I now know that for the equation to balance what I do to one side of the equal sign must do the same to the other side. For example:

$$2x - 4 = 6$$

$$2x - 4 + 4 = 6 + 4$$

$$2x = 10$$

$$x = 5$$

The game play simplified the difficult algebra concepts as echoed by Learner 2. Star and Selfort (2006:290) asserts that algebra can be a wellspring of significant disarray and negative perspectives among learners: one reason for this state of affair was that learners seemed to find algebra difficult to understand. When learners find something difficult to understand, they often become confused and bored. Online mathematics games simplified the algebraic concepts and aroused the learners' interest in Algebra.

Learner 3 claimed that:

The moment the teacher starts talking about Algebra my mind used to switch off. It was really difficult for me. Even my parents found it difficult to understand. The use of online mathematics games really helped me a lot. I like playing computer games and this method is helping me improve my focus in mathematics. Though am still struggling in some areas like con-joining $x + y = xy$ *, I have improved a lot in the other areas. Maybe it`s now like this because the teacher used something (playing games) I enjoy doing.*

Learner 1holds the view that:

The use of online mathematics games really pushed me to work very hard. At first I didn't understand how to play Dragon box and as a result I would be stuck at the starting level. I had to practice more so that I can also compete with my fellow learners who were going all the way to the final levels. After two weeks of playing Dragon box, I came to an understanding that when dealing with Algebraic equations both sides of the equal sign are equivalent. The same sentiment was echoed by Mann (2004) who posits that helping learners understand the possibility of identicalness can be grown solidly utilizing material articles and representations to adjust idea of the equivalent sign. I hope teachers will also use online mathematics games all the time.

From the interview responses, it is plain that online mathematics games enabled learners to comprehend algebra as a comprehensible language:

learners were able to comprehend the notion of a variable, variable expression and the meanings of solutions.

Another participant, Learner 5 stated that:
I always got confused with expressions such as $7x + 2$ *because I did not understand the language of Algebra. I took "*x*" as a multiplication sign not a variable so* $7x + 2$ *I used to get 14. But now after playing Dragon box and Algebra Meltdown together with the teacher`s explanations, I now know that "*x*" is a variable not multiplication sign. The expression will be* $7 \times x + 2$ *with "*x*" as an unknown. This was discussed in chapter 2 that learners are facing difficulties in Algebra because they do not have a solid comprehension of the images they are utilizing. Step by step instructions to decipher images or numbers that are composed close to one another can be challenging for learners (Van de Walle et al, 2013:257).*

Learner 6 went on to state that:
I used to have problems of understanding variables. I did not know that variables take on different meanings, depending on the context. Now I know that $x - 1 = 2$*, "*x*" is the unknown and "3" is the solution to the equation.*

After using the online mathematics games, learners were able to interpret the symbols. Before using online mathematics games, learners had a misconception of the variable x as standing for multiplication. After using online mathematics games, learners discovered that the expression $28x + 4$ meant that 28 was multiplied by x and then 4 was added.

Learner 3 affirmed that:
For an expression like $2(a + b)$*, I did not know that* a *and* b *are used to generalise a pattern. I used to get* $4ab$ *as my answer. But now after game play, I now understand the context* $2(a + b) = 2a + 2b$*. This is in support of what was discussed in chapter 2, according to Van de Walle (2013:257), the factors used in polynomial mathematics take on various implications relying on setting. In the equation* $4 + x = 6$*, "*x*" is the unknown and* 2 *is the solution to the equation. But in the statement* $A(x + y = Ax + Ay$*,* x *and* y *are being used to generalise the*

pattern. Failure by learners to understand the contexts leads them to have difficulties in solving algebraic expressions and equations.

These investigations were significant because one had to know whether the learners were acquainted with online game play and whether they understood the purpose of using online mathematics games.

By interviewing the learners, the researcher was cross-validating the observations he made during lessons. The learners accepted that online mathematics games positively affected their understanding, focused their skills as well as motivation. The following are some of the comments which prove the above views:

Learner 1
I used to find Mathematics as difficult and boring maybe because I was not understanding the concepts. Sometimes when the teacher was teaching I used to doze off but now I am more than motivated than ever. I like playing games. Game play is my DNA…

Learner 2 commented as follows:
When our teacher introduced game play in our Algebra lesson, I started looking forward to the next lesson because the lessons were now vibrant, accommodating and inspiring. I now understand more the Mathematics concepts than I was when we were using the textbooks only. Game play during lessons is the right way to learn Mathematics.

From the interviews, it can be noted that the learners were reporting more on the positive effect of the online mathematics games on their achievements and inspiration.

Learner 4 stated that:
I *enjoyed playing Dragon box and Algebra Meltdown, but the problem was there was no way to ask questions during game play. It became so frustrating when you do not know what to do next. If you take time to play, then eventually you lose the game.*

The same sentiments was echoed by Low et al (2010:236) when he said that this lack of communication, discussion, interaction and feedback can also lead to frustration, Learners had to enter an explanation of what they saw but, again received no feedback…Essentially the learning objectives became a frustrating test and no fun.

Learner 5 commented that:
The first week the game play made me feel embarrassed. Most of the learners were advancing to the next levels whilst I remained at the first level. Though the teacher kept on guiding and explaining how to play, as I kept on playing, I ended up being angry with myself. Learners might need to play until they win or advance in the game. This assurance by the learners can cause low confidence or forceful conduct particularly if the child continues losing at the game (Anneta et al, 2009:80).

Although a few learners had negative responses towards online mathematics games, the interviews showed that online mathematics games to a greater extent changed the state of mind of most of the learners: from (i) a lacking understanding of basic ideas in Algebra, namely variables, algebraic expressions and equations, to (ii) fully understanding the Algebraic concepts involved and (iii) experiencing the joy of solving problems and learning which system to apply and for what reason it is pertinent (Jupri & Drijvers, 2016:2). Learners turned out to be more mindful of the relations among Mathematics and reality, and their dread of variable based mathematics reduced.

All of the interviewed learners revealed that they preferred playing the online mathematics games. Online mathematics games removed them from the class, changed their disposition and were engaging. The experience and investigation angle of the online mathematics games made them fascinating. The difficult viewpoint of the online mathematics games was absorbing. The blend of tackling issues, and learning mathematics through gaming made games appealing. The way that online mathematics games joined fun and learning mathematics was significant and online mathematics games showed learners a distinctive technique for learning mathematics (Afari et al., 2012:131).

4.5. Observations

Classroom observations permitted me to see how teachers and learners used online mathematics games during mathematics lessons. As the participant observer, I was immersed in what was happening in the classroom when the teacher was teaching and providing optimal learning experiences to the learners in the classroom. The observations provided a ‘snap shot’ of the level of learner engagement in a particular lesson. The researcher observed that participation levels of learners were high: they were doing the online lesson because they were active participants and the online mathematics games aroused their interest and allowed them to focus. The lessons taught were stimulating and engaging for the learners. Due to this environment, learning through game play, learners as active participants, learners were able to link online mathematics games with algebraic concepts.

During classroom observations, I observed that the chosen participants, teacher as well as learners, showed willingness and preparedness to use online mathematics games in the classroom. I observed that online mathematics games made it possible for the teacher to understand that learners were dynamic cognising specialists who needed to gain information by drawing in with the setting instead of exclusively through transmission. Engel Brecht et al. (2009:927) claims that the above sentiments tally well with theories used in this thesis, Activity theory, Socio-Cultural theory, Socio-Constructivism which state that information is indistinguishable from practice. Learners understand better by doing algebra in a fun way and manipulating tools and signs themselves at their own pace. Learners became active instead of passive participants.

The following table indicates whether learners had played online Mathematics games before, either in a classroom setting or at home.

Table 4. 4: Show learners who have played online mathematics games

Participants	Played online mathematics games		Frequency
L1	YES		Nearly everyday
L2	YES		Occasionally
L3		NO	Never
L4	YES		Everyday
L5	YES		Nearly everyday
L6	YES		Everyday
L7	YES		Everyday
L8	YES		Occasionally
L9	YES		Nearly everyday
L10		NO	Never
L11	YES		Everyday
L12	YES		Everyday
L13	YES		Everyday
L14		NO	Never
L15		NO	Never
L16		NO	Never
L17		NO	Never
L18	YES		Nearly everyday
L19	YES		Everyday
L20	YES		Everyday
L21	YES		Occasionally
L22	YES		Everyday
L23	YES		Nearly everyday
L24		NO	Never
L25	YES		Everyday
L26		NO	Never
L27	YES		Everyday
L28	YES		Nearly everyday
L29		NO	Never
L30		NO	Never

Source: Primary data

The table above shows that 80% of learners had played online mathematics games before and only 20% had not played the online mathematics games yet. Those who had not played online mathematics games gave reasons for not having smart phones or laptops; while 80% had. The purpose of the table was to show whether there was a problem or whether a learner was struggling to go to the next level. The researcher will know if the learner is fully conversed with game play or not.

The observation sheets below indicate what transpired in the classroom as the learners were doing Algebra by using Dragon box and Algebra Meltdown.

Observation Sheet

If learners are being engaged

Engaged means learners are being active. The learners are paying attention, alert, listening and taking notes as the teacher explains how the lesson will be conducted. The learners were asking questions as well as responding to teachers questions, Johnson (2013) said that to increase learners engagement the teacher needs to increase learner activity. The teacher made it so engaging that it was difficult for learners not to participate.

Time spend by learners on tasks

The teacher allocated time for playing the online mathematics games (Dragon Box, Algebra Meltdown, IXL). The teacher did try to remove distractions but since the teaching method was at infancy level most of the learners could not go to the next level of the games which was being used in the lesson.

Learners` sequence of actions

Learners sequence of action means ordering learners learning activities. Since sequencing requires high order thinking skills (Johnson, 2013) from recognising symbols and patterns to determine cause and effect of a particular task. At first the learners were failing to decipher how to sequence their actions when playing online mathematics games.

Learners request for help

Individual attention ⇒ the learners felt comfortable seeking help or asking questions. This was so because the teacher had created a conducive environment for learning. Most of the learners were asking for help because they were having problems understanding the rules.

Communication

At first the teacher articulated his expectations to the learners. Both teacher and learners were active listeners. Communication was effective which benefitted both the teacher and learners. Effective use of online Mathematics games can elicit, encourage and extend learners communication and collaboration in learning. (Murray, 2001: 29)

Observation Sheet

If learners are being engaged

If true learning is to occur, then learners have to be at the very least participants in the process and not merely products (Johnson, 2013). What makes the lesson engaging is the high relevance of the online mathematics games, positive rewards (going to next level), learners well prepared and warm-up (engaging learners physically and intellectual activities before teaching. The ultimate engagement is to put the learner in charge of learning. Online mathematics games were creating a rich learning environment and a motivation to learn (Murray, 2008, 28)

Time spend by learners on tasks

The time allocated for the online mathematics games was sufficient which had a high positive achievement compared to the first lessons. The games captured the learners imagination encouraging them to stay focused. It was of paramount importance that the teacher allocated sufficient time to allow the learners to master the rules of the game and to link the algebraic symbols and patterns exhibited on the games (Dragon Box, Algebra Meltdown).

Learners` sequence of actions

The learners sequencing of actions is now logical. The learners are now able to recognise Algebra symbols and able to link them with symbols and patterns in games. I noted that when learners are able to sequence events logically they will be able to understand and organise material they have learned as well as helping them solve problems (Algebra).

Learners request for help

Learners are no longer asking teachers help since they are now comfortable doing the activities on their own. They have now mastered the game rules and some of the algebraic concepts which were difficult at the beginning.

Communication

Communication was effective which benefited both the teacher and learners. The teacher encouraged the learners to initiate and engage in conversations which made learning easier. Feedback was given. Communication makes learning easier, helps learners achieve goals, increase opportunities for expanded learning, strengthens the connection between learner and teacher and creates a positive experience (Johnson, 2013).

By making careful observations, the researcher noted that online mathematics games allowed learners to develop their eye-hand coordination concentration levels, visual segregation, and retention, capacity to convey and utilize numerical language (Murray, 2001:29).

The feedback that learners received from online Mathematics games was summative (Gee, 2003). I observed that as the learners completed a certain level, they advanced to the next level. According to Garris et al. (2002:454) the questioning procedure is critical in changing game occasions into learning experiences. For successful learning to occur, it is critical to survey and break down occasions, for example, (i) the depiction of occasions that happened in the game, (ii) examination of why they happened and (iii) conversation of mix-ups and restorative activities (Garris et al., 2002;454).

The concentration levels of learners were high because they wanted to pass the game levels. I could see that learners were engrossed in the work and this prompted me to ask probing questions. Spaull (2013:4) clarifies that when certain parts of an encouraging procedure or learning process are discarded, holes show up between what learners should know and what they do know. The use of online mathematics games in many cases bridged important gaps.

During observations, the researcher noted that feedback was essential because it encouraged and motivated learners to be active participants. This observation in turn helped learners to process new mathematics concepts [$3 + x$ is not equal to $3x$ but it remains $3 + x$, $2\{x + y\}$ is not equal to $2xy$ but $2x + 2y$ (Vermeulen, 2000)] and information. Feedback allowed participants to assess their progress and determine areas needed for self-improvement.

The researcher, in trying to summarize what the participants wrote on their questionnaires, asked them how they felt about online mathematics games. The following picture shows the responses of learners:

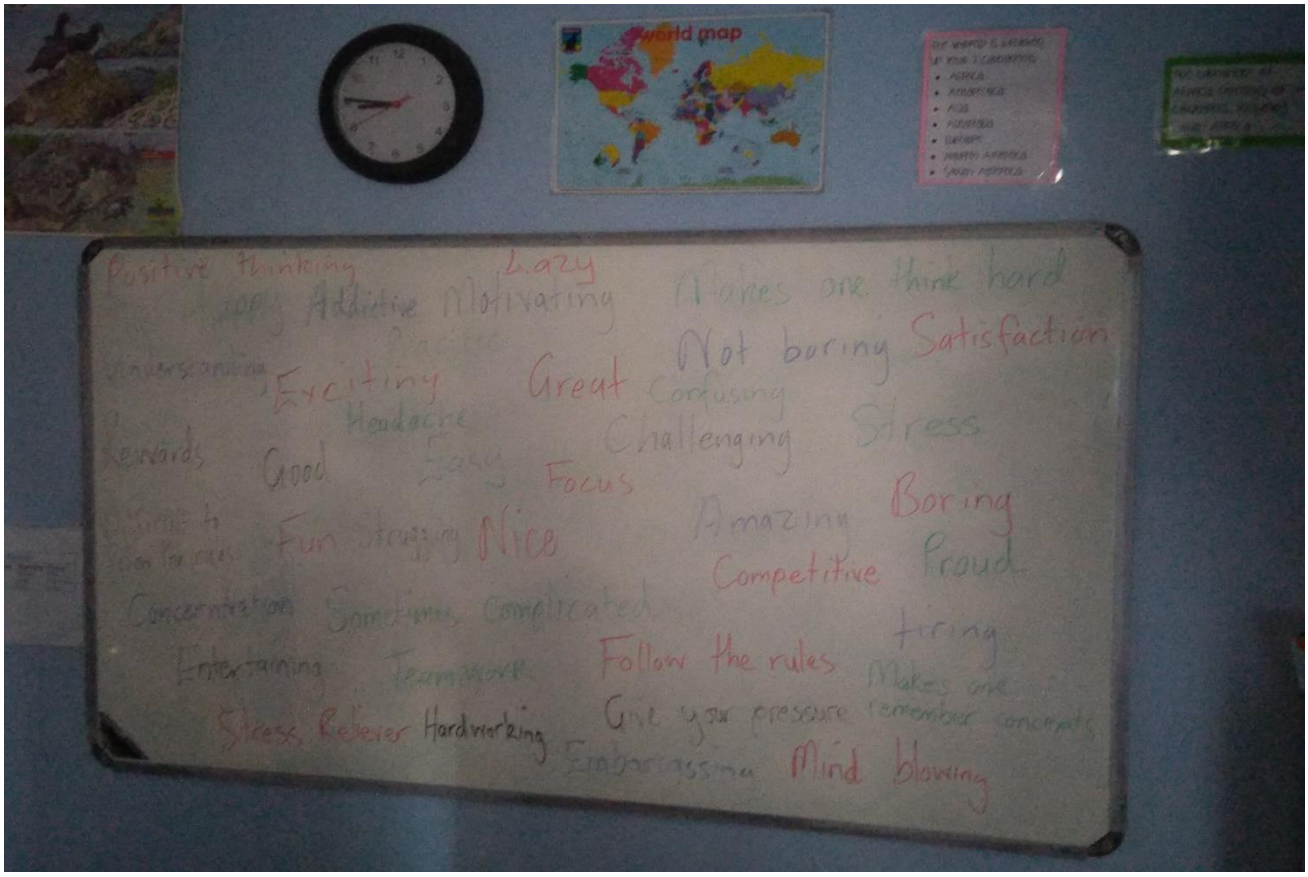


Figure 14 Themes from learners` questionnaire responses

The image above depicts the following responses about online mathematics games from the participants' questionnaires:

motivating, follow the rules, mind blowing, enthusiasm, positive thinking, makes one remember concepts, understanding, addictive, total involvement, excitement, enjoyment, boring, hardworking, great, tiring, competitive, exciting, headache, focused, rewards, give you pressure, makes one think harder, good, stress, easy, proud, lazy, concentration, entertaining, struggling, stress reliever, amazing, embarrassing, practice, satisfaction, sometimes complicated, teamwork, fun and nice.

From the participants' responses, the researcher discerned three themes. The researcher grouped the above responses under the three themes: stimulating cognition, motivation and hindrances to learning. This grouping is shown in the table below:

Table 4. 5. Analysis of questionnaire responses

Stimulating cognition	Motivation	Hindrance to learning
Follow the rules	Exciting	Addictive
Positive thinking	Enjoyment	Sometimes complicated
Makes one remember concepts	Great	Boring
Understanding	Mind blowing	Tiring
Easy	Rewards	Headache
Practice	Good	Gives you pressure
Total involvement	Proud	Stress
Hardworking	Entertaining	Lazy
Competitive	Amazing	Struggling
Focused	Satisfaction	Embarrassing
Makes one think hard	Fun	
Concentration	Nice	
Stress reliever	Enthusiasm	
Teamwork		

Taking a closer look at participants' responses, it may be deduced that to considerable extent, online mathematics games can play a crucial role when doing algebra. Games stimulate cognition, motivate the learners and promote learning in a relaxed, fun way.

This section has introduced the principle discoveries of this research. By analysing the phenomenon from various angles, the data showed how participants embraced online mathematics games as a means to enhance their understanding of Algebra. Responses were varied and reflected individual progression in terms of how each participant developed her or his skills, knowledge of game play and confidence in their abilities, and depended largely on participants' personal motivation. The data further illuminate how online Mathematics games interact with existing pedagogies, classroom norms, and how they might change the possibilities for knowledge building and new forms of learning. The case studies selected outlined how individual participants optimised the affordances of online Mathematics games skills for educational instruction.

Chapter 5: Summary, Conclusion and Recommendations

5.1. Introduction

This section presents an outline of the discoveries, present a summary of the findings and make a few proposals for future research around the contribution of online mathematics games in helping learners understand algebra. The core question of this investigation was how online Mathematics games can be used to better understand algebra and entrench algebraic concepts. This study considered the games Dragon box and Algebra Meltdown for improving knowledge of algebra. In this chapter I report upon the discoveries and conclusions that rose up out of this investigation, and their implications for integrating online Mathematics games into classroom teaching.

Following on from the literature review on gaming, I elaborated upon the two scaffolds that emerged from the data. The first scaffold points to learners' personal views on online Mathematics games. The second scaffold underpins the importance of grafting appropriate online Mathematics games onto the current CAPS curriculum for algebra. Sustainability and continued use of integrated technology at the research site rely chiefly upon these two scaffolds. This part sums up and ponders the outcomes introduced in Chapter 4. This section proceeds to think about the constraints of the investigation and its impact, propose roads for additional exploration, makes suggestions and gives a conclusion.

5.2. Summary of previous chapters

This investigation was designed to examine the value of online mathematics games for improving the understanding of algebra at grade 8 mathematics level. The point of the investigation was to decide (i) if online mathematics games contribute to learners’ understanding of algebra and (ii) how online mathematics games increase appreciation of algebra in grade 8 mathematics at a school in the Western Cape Province of South Africa. The research discussed previous literature and developed a credible, reliable theoretical framework to (i) discuss online mathematical games, (ii) reasons for using online mathematics games and (iii) understanding of algebra.

As an underpinning theoretical approach, I synthesized Activity theory, Socio-cultural theory and Socio-constructivist theory as a ‘conceptual lens’ with which to interpret and categorise the unique qualities of online Mathematics games. Teachers and learners can draw upon this framework to instil and deepen a sound understanding of Algebraic principles and applications in a pleasant and relaxed way. The theories that were employed allowed me to (i) connect mediation tools, such as online Mathematics games, to Algebraic content and (ii) describe how the connection between mediation tools and Algebraic content can interact with one another to produce a deeper understanding of basic formulations.

Once technological infrastructure was supplied to the classroom for access by the learners, there was a further need to understand how online Mathematics games translate into embedded classroom practice: fortunately, use of technology requires a learner-centred approach which is the basis of CAPS. Information was gathered through classroom observation, questionnaires and interviews with the assistance of audio recordings. Various research techniques empowered the researcher to secure the validity of information gathered through triangulation.

The research findings showed that online mathematics games increased clarity, understanding and explanation of basic algebraic concepts. Online mathematics games played in class indicated that not all learners knew how to play online mathematics games at first (Table 4.5). Most of the learners encountered problems in understanding the rules/demands of the online mathematics games.

5.3. Summary of research findings

This investigation assessed the value of mathematics games in increasing understanding of Algebra at the grade 8 Mathematics level. The findings strongly suggest that some learners saw the utilization of online mathematics games in the learning of algebra as initially intimidating because some of the online mathematics games involved complicated symbols, steps and rules which made it difficult for them to link algebraic concepts (Chapter 4).

Participants` responses, however, illustrated the benefits of using online Mathematics games in Algebra lessons. For instance, online Mathematics games assisted learners to correct their own flaws in Algebra at their own pace in an unthreatening pedagogical environment: e.g. conjoining $(3 + x = 3x)$, overgeneralisation of the distributive property $(2\{x + y\} = 2x + y)$ (Vermeulen, *2000).* L3 stated that for an expression such as, $2(\mathrm{a} + \mathrm{b})$, '*I did not know that* a *and* b *are used to generalise a pattern. I used to get* $4ab$ *as my answer. But now after game play, I now understand the concept of* $2(a + b) = 2a + 2b.$*'* This observation supports Natale (2002:26) who affirms that cerebrum motions, related with navigational and spatial learning, happen all the more every now and again in more unpredictable games. These elevated brain functions surge clients` learning and memory capacities and support more important scholarly, social computer proficiency aptitudes.

The researcher uncovered during interviews that the learners faced numerous difficulties such as (i) lack of motivation, (ii) not understanding the mathematical language and concepts, and (iii) fear of ridicule in an orthodox learning environment; all of which inhibited their understanding of Algebra. Many did not understand the concept of the symbol and the equal sign (Van de Walle et al., 2013:258). This lacking brought about learners not being at the stage they should be scholastically. L2 stated "*I didn't really understand what equivalence was. The Dragon box really helped me a lot because it simplified the Algebraic concepts into a game*". Another participant L6 asserted that '*I did not know that variables take on different meanings depending on the context. Now I know that* $x - 1 = 2$*, 'x′ is the unknown and ′3′ is the solution to the equation'*. A learner responded that '*I used to find Mathematics as difficult and boring maybe because I wasn`t understanding the concepts. Sometimes when the teacher was teaching, I used to doze off but now I am more than motivated than ever. I like playing games. Game play is my DNA'.*

Looking at the learners' comments, I came to the conclusion that online Mathematics games can definitely improve learners' understanding of, and performance in, Algebra as long as the games to be used are judiciously selected and their deployment is closely aligned with, and integrated into, the CAPS guidelines

provided. Such games should be used for learners to better understand mathematical concepts (Polly, 2012:81).

During classroom observation, it was noticed that the learners had the option to work in clusters, partake, operate at different levels and manipulate algebraic concepts with the help of online mathematics games. They did not fear being laughed at, which is what happens sometimes when some learners offer solutions in an open class: they could work at their own pace which is in line with the constructivist spirit of CAPS pedagogy. Wiersum (2012:25) propounded that online Mathematics games allow learners to work at various degrees of deduction and to gain from one another. The learners` participation levels were high since they were active participants and doing something they were enjoying. This experience was echoed by *L1 who claimed that the utilization of online mathematics games really pushed me to work very hard. At first I didn't understand how to play Dragon box and as a result I would be stuck at the starting level. I had to practice more so that I can also compete with my fellow learners who were going all the way to the final levels. L5 stated that the first week the game play made me feel embarrassed. Most of the learners were advancing to the next levels whilst I remained at the first level.* Online Mathematics games made it possible for the teacher to accommodate learners with different capabilities. By letting learners work at different levels, a high degree of interest is generated (Mayer et al., 2002:172).

5.4. Recommendations

This research provides a platform for integrating online mathematics games into the teaching and learning environment for all conventional mathematics topics. Based upon the findings and caveats of this research, teachers may safely encourage learners to use online mathematics games in the learning of algebra because online mathematics games help learners to be innovative, to search for designs, make guesses, collect data, express their own contemplations, acknowledge the thoughts of others and set up types of collaboration (Siemon et al., 2016:11). Further research needs to be led on a larger scope with numerous schools in different areas to test these findings about the value of online mathematics games in educating algebra at

the grade 8 Mathematics level. In addition, the research should be conducted over a significant stretch of time.

In the light of these findings, and with the necessary reservations about cautious selection of games and how to deploy them with due respect to the guidelines set out in CAPS, the school mathematics curriculum could be reviewed to integrate new instructing and learning methods that allow learners and teachers to deploy online mathematics games in teaching and learning Algebra. When choosing online mathematics games, teachers should ensure that mathematical concepts are presented accurately and that the content/materials do not distract learners from the concept to be learnt. The online mathematics games allow learners to interact with different situations and to think logically about outcomes.

This finding was supported by the National Research Council (2001:115) which affirmed that online Mathematics games can be basically fabricating squares to grow scientifically capable learners who understand Mathematics concepts. Murray (2001:28) went further to posit that online Mathematics games are effective at the point when they are utilized to empower learners to think and make associations between the items and the theoretical Mathematics ideas. Teachers should evaluate the software judiciously and choose online mathematics games that allow learners to think rather than simply practise algorithms. According to NCTM (2000:16) the vital concern is whether instructors comprehend the benefit of utilizing online mathematics games to teach algebra, what`s more, the reason behind the utilization of such online mathematics games as, “effective mathematics teaching entails understanding what the learners know, what they need to learn and then challenging and supporting them to learn it well”. The findings of this research are helpful to novice and expert teachers alike, in improving the initial teaching of algebraic concepts.

Further research may be conducted into online mathematics games as a contributor to teaching and learning. Teachers should be given training in the pedagogy of integrating online mathematics games. The Department of Education could organise seminars to be attended by teachers and learners to explore more online mathematics games and their effectiveness in the classroom. On the basis of this

investigation, school policy makers and syllabus designers may usefully include more online mathematics games into the curriculum.

These discoveries show that learners invest a lot of energy playing advanced games and will in general relate to the characters they adopt or take on in the course of playing the game. Along these lines, we have to additionally look at what schoolboys and schoolgirls lean toward in games so as to create instructive internet games which suit diverse character types and, all the more critically, misuse numerous abilities and insights, in evident impression of genuine cooperative situations, in the context(s) of learning algebra specifically and mathematics in general.

According to Paraskeva et al. (2010:503) online mathematics games must negotiate the difficult area between engaging the initial interest of learners, without becoming addictive and unfavourable to scholastic execution. I made a proposition that this could be achieved by integrating elements that limit play sessions and oblige learners to engage effectively in an outside instructive errand before proceeding with play, in a perfect world as a team with different learners. On the other hand, the online mathematics game itself can work as the premise for an innovative and motivating schoolwork task.

The relation between online mathematics games use and self-esteem cannot be clearly defined yet, since research so far has only yielded conflicting or ambiguous results (Paraskeva, 2010:503). Given the critical job of confidence in scholarly execution and social alteration, however, it is worthwhile to research the issue further. Finally, the suggested potential of games with regard to improving understanding of algebra is an encouraging finding and should be more fully exploited.

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Appendix A: Observation Sheet

If learners are being engaged

Time spend by learners on tasks

Learners` sequence of actions

Learners request for help

Communication

Appendix B: Questionnaire Guidelines

Thank you for consenting to answering this questionnaire. The purpose of this questionnaire is to find out if online mathematics games help learners in understanding and solving algebraic questions. Your co-operation in this regard and responses are greatly appreciated. Your responses will be completely anonymous.

i. Please answer all the questions.

1. What do you understand by online mathematics games?

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2. Do you think learning without online mathematics without games is boring?

Yes ☐ No ☐ Explain your answer.

_____

3. Do you feel comfortable playing online mathematics games?

Yes ☐ No ☐ Explain your answer

_____

4. Do online mathematics games contribute in understanding abstract concepts?

Yes ☐ No ☐ Explain your answer

_____

5. Do you feel the use of online mathematics games helped you in understanding algebra better?

Yes ☐ No ☐ Explain your answer

_____

6. Online mathematics games increase concentration levels of learners during lessons?

Yes ☐ No ☐ Explain your answer

_____

7. Do online mathematics games arouse your interest in class?

Yes ☐ No ☐ Explain your answer

_____

8. What do you like or dislike most about online mathematics games?

_____

_____

_____

9. Is algebra difficult without being taught using online mathematics games?

Yes ☐ No ☐ Explain your answer

_____

_____

_____

Appendix C: Interview Guidelines

The context is I am examining the contribution of online mathematics games to Algebra understanding in grade 8 Mathematics.

Interviewer: …… Interviewee: …….
Time: …… Date: …….
Place: ……

The interview will take less than 10 minutes. All your responses will be recorded so that no information will be lost or misinterpreted. All the information will be kept confidential. Take note that, you don't have to divulge any information you don't want to and you may end the interview at any time.

1. Describe what you know about online mathematics games?
2. Do you find it easier to understand Mathematics when taught using online mathematics games?
3. Are you comfortable learning mathematics using online mathematics games? Why/Why not?
4. Do you consider the use of online mathematics games in the mathematics classroom as a necessity for learner achievement in mathematics? Explain how?
5. Are you motivated to use online mathematics games more often to enhance your understanding of algebra?
6. Do you think that your performance was enhanced by the use of online mathematics games? Explain how?

Thank you for your cooperation and time.

Appendix D: Letter requesting permission from the principal

Cape Peninsula University of Technology
Mr / Mrs / Ms……
…….
…….

Dear Mr / Mrs / Ms……

Request permission to observe your child for my masters research project

I am with Cape Peninsula University of Technology where I am currently doing Master`s degree. My research topic is:
“The contribution of online mathematics games to algebra understanding in Grade 8”.
I would like to obtain your permission to observe your child during Mathematics classes, giving a questionnaire to fill in and responding to interview questions. My role is to observe your child`s use of online mathematics games to solve algebra problems. I will not in any way disrupt his/her learning process. I will kindly require you to sign this consent form which gives me your permission to continue with this research.
All the information obtained from my observation and the questionnaires will be kept strictly confidential. The above arrangement can be terminated at any time. The research project, when completed, will be available for you to view. Please note that no where will you or your child`s identity be revealed. Pseudonyms will be used. Please feel free to contact me if you need any additional information regarding this research.

Yours Sincerely,

Tichaona Marange
(0832062096)

I, Mr / Mrs / Ms…… give permission for my child, _____(name) to participate in the research project.

Signature……. Date……

Appendix E: Consent letter for parents/guardians

Cape Peninsula University of Technology
Mowbray Campus
Highbury Road
Mowbray

29 March 2018

The Principal
Emmanuel Christian Academy
7 Dingle Road
Goodwood

Dear Sir

PERMISSION TO CONDUCT RESEARCH AT YOUR SCHOOL

I am currently with Cape Peninsula University of Technology where I am doing a Master`s degree. My research topic is: “The contribution of online mathematics games to algebra understanding in Grade 8”.

I am kindly requesting your permission to do research at your school. Information will be collected using observations, interviews and questionnaires to be administered to Grade 8 learners. All the information obtained will be treated as highly confidential and when completed the results will be available to you to view. The results will help the school improve the Maths results at your school.

I hope that you will grant me permission to do the research at your school. The following are my contact details: 083 206 2096, if there is any query or concerns which you want to discuss with me.

Yours Sincerely

Tichaona Marange