
# EXPLORING THE EFFECT OF CHESS GAMES TO IMPROVE PERFORMANCE OF SENIOR PHASE LEARNERS IN MATHEMATICS

By

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## DECLARATION

I declare that the dissertation EXPLORING THE INFLUENCE OF CHESS GAMES TO IMPROVE PERFORMANCE OF SENIOR PHASE LEARNERS IN MATHEMATICS, hereby submitted for the qualification of Master's degree at the University of the Free State, is my own independent work and that I have not previously submitted the same work for the qualification at/in another university.

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G.E MATHE DATE

Supervisor: Prof MOGEGE MOSIMEGE

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Thank you all. I could not have done it without your support!

## DEDICATION

This dissertation is dedicated to my loving mother, Mrs Amelia Maipato Litheko, who was always behind me, supporting me and confident that I will succeed. I also dedicate it to my younger sister Keamogetswe Litheko, my younger brother Tebogo Litheko, my beautiful daughters Khanyisile Mathe and Khwezi Mathe, and my only son Lukhanyo Mathe.

## ABSTRACT

Studies have been carried out on the influence of chess games on the performance of learners in mathematics. This study aimed to explore the impact of chess games on learners' mathematics understanding in the Senior Phase, learners' engagement in chess lessons and how knowledge gained in these games helps them to transfer to solving mathematics problems. The participants in this study were the Senior Phase mathematics learners. This study was informed by the phenological research design. The literature revealed that learners' engagement in chess games led to an improvement in developing problem-solving skills with mathematics problems, which is more prevalent in those grades. The researcher adopted the constructivist theory and interpretivism research paradigm.

Data were collected from 17 Grade 7 learners using semi-structured interviews, video recordings and observation sheets. Interview forms were distributed to the learners to determine their engagement during chess games. The research specifically explored how learners compete against one another as they engage in chess games. The learners were observed on how they move chess pieces. The qualitative research was utilised, and data was analysed using thematic analysis.

The research findings revealed a positive influence of chess games on the transferability of knowledge gained by learners in solving mathematics problems. Recommendation is that chess games should be used to enhance the teaching of mathematical concepts such as number patterns. Chess games have patterns which learners can also apply in understanding number patterns in mathematics as stipulated in CAPS document.



**KEYWORDS:** Affective engagement, chess games, cognitive development, constructivism, transferability of knowledge.

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## LIST OF ABBREVIATIONS/ACRONYMS

| | |
|---|---|
| ANA | Annual National Assessments |
| ATP | Annual Teaching Plan |
| CAPS | Curriculum and Assessment Policy Statement |
| DBE | Department of Basic Education |
| FSDoE | Free State Department of Education |
| EMIS | Education Management Information System |
| LoLT | Language of Learning and Teaching |
| NCTM | National Council of Teachers of Mathematics |
| SACMEQ | South African Consortium for Monitoring Education Quality |
| SA-SAMS | South African School Administrative Management System |
| SMT | School Management Team |
| STEM | Science, Technology, Engineering and Mathematics |
| TIMSS | Trends in International Mathematics and Science Study (TIMSS) |
| UFS | University of the Free State |
| ZPD | Zone of Proximal Development |

# CHAPTER 1
# INTRODUCTION AND OVERVIEW OF THE STUDY

## 1.1 INTRODUCTION

This study aimed to explore how chess games influence the understanding of mathematical concepts of primary school learners. This chapter outlines the study, starting with a brief background to contextualize the problem statement. Furthermore, it provides research questions, aims and objectives, motivation and significance of this study, trustworthiness, chapter summary and layout of the chapters in this study.

## 1.2 BACKGROUND TO RESEARCH

Poor learners' performance in mathematics is a worldwide educational problem (Potgieter, 2020), affecting learners' overall performance, but more so in the Science, Technology, Engineering and Mathematics (STEM) subjects where a good grasp of mathematics determines whether a learner will pass or fail (Trinchero & Sala, 2016). Educating learners in STEM subjects prepares them for life careers, irrespective of the profession they choose to follow (Subia, Amaranto, Bustamante & Damaso, 2019), implying that learners' inability to understand mathematics presents challenges for the global job market and the overall economy of a country.

The researcher believes South Africa needs to be more competitive in the performance of learners in mathematics compared to other African countries and the world at large. Strong worldwide economies show the highest performance trends in International Mathematics and Science Study (TIMMS). The countries that perform well in TIMMS include Singapore, the Korean Republic, Chinese Taipei, Hong Kong and Japan (Reddy, Visser, Winnaar, Arends, Juan, Prinsloo & Isdale, 2016). TIMMS is generally respected in international testing programs to evaluate whether countries are making educational progress over time (DBE, 2015). The findings by Mullis, Martin, Foy, Kelly and Fishbein (2020) show that South Africa was amongst the five lowest-performing countries in mathematics achievement in a sample, including Botswana, Jordan, Morocco and Saudi Arabia.

The South African Consortium for Monitoring Education Quality (SACMEQ) revealed that South Africa's performance in mathematics is ranked number eight out of 14 countries, behind poorer nations such as Tanzania, Kenya, and Swaziland (Reddy et al., 2019). The quality of education in South African schools is characterized by various challenges, which include insufficient resource allocation to schools and inappropriate teaching methodologies in mathematics to improve learner performance (Sibaya, 2019).

In addition to inadequate teaching methodologies, poor problem-solving skills among learners may also affect their performance in mathematics (Okitowamba, 2016; Sala, Gorini & Pravettoni, 2015; Venkat & Spaull, 2014). Problem-solving skills also affect learner performance in concepts inside and outside mathematics terrain (Okitowamba, 2016). Different studies have therefore investigated ways to solve the South African learners problems with mathematics mastery, ranging from new methodologies to using games to help learners understand Mathematical concepts (Mosimege, 2020; Mwapwele & Roodt, 2018).

Learners' problem-solving skills might improve when they engage in sports such as chess games. Chess games have been claimed as one of the instruments to strengthen learners' mathematical abilities (Sala, Foley & Gobet, 2017; Sala & Gobet, 2017). Several studies have been conducted to ascertain the effectiveness of chess games in improving the academic performance of learners in mathematics (Mel, 2021). The research gap lies in the fact that most primary schools do not provide access to chess games for Grade 7 learners which helps them to understand mathematical concepts. Several research indicates the effectiveness of chess games on learner performance however they do not indicate the learners understanding of mathematical concepts. Most countries internationally have incorporated chess games within their curriculum because studies indicate that chess games improve learner performance in mathematics however, until now, chess games have not yet been included in the mathematics curriculum of South African primary schools.

The current study explored the impact of the chess game in improving learners understanding of mathematics at the Senior Phase level.

## 1.3 PROBLEM STATEMENT

Learner performance in mathematics in Motheo district in the Free State Province indicates that out of 388 primary schools, only 78.3 % of schools managed to obtain between levels 4 and 7 in mathematics (EMIS, 2019). In addition, in the same district, the performance of Grade 7 learners of one school indicates that out of 99 Grade 7A learners who wrote the 2019 mathematics examination, only 32.3 % of learners obtained 50% and above (Level 4-7) (EMIS, 2019). Out of 110 Grade 7B learners of the same school who took the same examination written by Grade 7A learners, 75.5 % of learners obtained 50% and above (level 4-7) (EMIS, 2019). This indicates that Grade 7B learners perform better in mathematics than learners from Grade 7A of the same school. In addition, most learners who performed well in Grade 7B had taken chess as their extra-curricular course for one year, while the learners of Grade 7A had regular lessons and were never taught chess as their extra-curricular class.

The report released by Motheo district on the performance of learners in mathematics was the basis for the researcher's interest in this study. As a result, this has captured my interest in exploring the influence of the game of chess in improving primary school learners' understanding of mathematical concepts in Motheo District. The research gap lies in the fact that most primary schools do not provide access to chess games for Grade 7 learners which helps them to understand mathematical concepts. Several research indicates the effectiveness of chess games on learner performance however they do not indicate the learners understanding of mathematical concepts.

According to Williams (2014), most countries internationally have incorporated chess games within their curriculum because studies indicate that chess games improve learner performance in mathematics (Gliga & Flesner, 2014). Other studies conducted suggest that chess games develop the problem-solving and analytical skills of learners and improve learners' performance in mathematics (Dvoryatkina & Simonovskaya, 2021; Sala et al., 2017; Burgoyne, Sala, Gobet, Macnamara, Campitelli, Hambrick; Sala & Gobet 2016). Most countries internationally have incorporated chess games within their curriculum because studies indicate that chess games improve learner performance in mathematics however, until now,

chess games have not yet been included in the mathematics curriculum of South African primary schools.

## 1.4 RESEARCH QUESTIONS

The following research questions guided this study:

Main research question

- What is the impact of the game of chess on the mathematical understanding of Senior Phase mathematics learners?

Sub-questions:

- How does chess games affect learners understanding of concepts in mathematics?
- How can the game of chess be used to improve the understanding of senior phase learners in mathematics?
- What is the relationship between the use of chess and learners' understanding of mathematics?

## 1.5 RESEARCH AIMS AND OBJECTIVE

The research aim of this study is as follows:

- To explore the influence of chess games on understanding of senior Phase learners in mathematics.

The following objectives are formulated:

- To explore the relationship between the use of chess games and learners' understanding of mathematics.
- To identify which learners' skills learned from the chess game.
- To examine the use of chess games in improving learners' mathematical understanding.

## 1.6 MOTIVATION FOR THIS STUDY

Firstly, as a member of the School Management Team (SMT) and currently monitoring mathematics at the Senior Phase level, I have observed firsthand the difficulties experienced by learners. Learners consistently experience difficulties when solving mathematical problems despite being taught the steps to be followed when solving these problems (Polya, 1945). Secondly, a critical measure of whether the school meets the national targets in South Africa is the learners' performance against benchmarks in core subjects such as mathematics and English in the Annual National Assessment (DBE, 2015)**.** The 2012 and 2014 ANA results indicated that Grade 9 performance in mathematics was well below expectations (DBE, 2015). FSDoE analysis of performance in mathematics conveyed that one school in a district have had trouble reaching annual national targets due to problems with mathematics. One school's analysis of performance in mathematics conveyed that Grade 7A in this school has had difficulty reaching annual national targets due to problems with mathematics (EMIS, 2019).

This analysis suggests that most learners in Grade 7A were not doing well in mathematics. My interest was raised after reading a series of studies advertising the benefits of chess. (Easvaradoss & Solomon, 2016; Joseph et.al., 2016; Sigirtmac, 2016; Gliga & Flesner, 2014; Hunt & Cangemi, 2014).

Chess may increase the problem-solving skills of learners (Sigirtmac, 2016; Sala et al., 2015) and may be used as a valuable tool to enhance learners' Mathematical performance (Rosholm, Mikkelsen & Gumede, 2017; Sala et al., 2015). Against this background, I found the chess and mathematics performance of Senior Phase learners necessary to this study's focus. Therefore, this study aimed to determine whether chess games may help improve the performance of Senior Phase learners in mathematics.

## 1.7 SIGNIFICANCE OF THIS STUDY

It was anticipated that the findings of this study may provide an opportunity to assist the Senior Phase learners in developing their mathematical performance problem-solving skills through chess games. The study turns to be important to mathematics teachers because it might highlight the benefits of chess games to assist learners of

Grade 7A to improve their mathematics performance. The study was also important to the researcher as a mathematics teacher because it might highlight the benefits of chess games to assist learners of the province in improving their performance in mathematics. Furthermore, the skills used in strategic games such as chess may be transferred to other learning areas, such as mathematics (Sigirtmac, 2016). The study may provide an opportunity for the other teachers of the Senior Phase regarding the advancement of learners' performance using chess games in the context of mathematics. In addition, the study may also highlight to the policymakers the importance of including chess games in the curriculum to advance performance in mathematics. This study will provide the SMT of schools, together with the stakeholders in the Motheo Education District, the opportunity to manage the implementation of chess games in their extra-curricular curriculum effectively to improve mathematics learning to achieve the set national goals in primary schools. activities. From the researcher's experience, chess clubs tend to have a low attendance rate. The researcher believes that if chess games are included in the South African mathematics curriculum, it might significantly impact learners' academic performance.

## 1.8 TRUSTWORTHINESS

To achieve trustworthiness in a qualitative research outcome, it is necessary to employ a systematic process in organizing and analysing data (e.g., coding, identifying shared themes, categorising themes, and demonstrating a clear theoretical or logical rationale for eliminating overlapping themes). As Bailey (2007:181) noted: "trustworthiness does not mean that the reader necessarily has to agree with the researcher; rather, it requires the reader to see how the researcher concluded". In order to ensure that this study is trustworthy, the researcher made research processes transparent and auditable so that others can understand and see how their findings were arrived at (Korstjens & Moser, 2018). According to Patton (2015), rigorous methods and the researcher's credibility are necessary for qualitative research to be trustworthy.

## 1.9 CHAPTER SUMMARY

The following aspects were dealt with in this chapter: background, problem statement, main research question, sub-questions, aims, study objectives, motivation, significance, theoretical framework, research approach, data collection techniques, data analysis trustworthiness and reliability, ethical consideration, value in this research, conclusion and structure of the study.

## 1.10 STRUCTURE OF DISSERTATION

The research was divided into five chapters.

Chapter One: Introduction and background of this study.

Chapter Two: Theoretical framework and literature review

Chapter Three: Research methodology and design of the study.

Chapter Four: Data presentation, analysis and interpretation.

Chapter Five: Discussion of results, conclusion and recommendations for further research.

# CHAPTER 2
# LITERATURE REVIEW

## 2.1 INTRODUCTION

This chapter reviews the literature on how chess games influence learners understanding of mathematical concepts. The literature is planned following the themes from the research questions. The literature review focused on the theoretical framework, research paradigm, constructivism and classroom practice, constructivism theory, the Zone of Proximal Development (ZPD), collaborative learning, and the origin of chess games. Chess and mathematics have been explained. The nature of mathematics concerning learners' performance in chess games was used as a basis for this study. After that, the discussion on the benefit of chess games in mathematics classrooms was stated as necessary for improving students' understanding of mathematical concepts. Finally, there was a brief overview of factors affecting mathematics learning; these factors include, among others, working memory, attitude towards mathematics self-concept, self-efficacy and anxiety.

The study aims to explore whether chess games can improve the understanding of mathematics of Senior Primary Phase learners of a selected school in Motheo district in Free State Province. The theoretical framework will also be applied to guide this study to achieve its aims and objectives. I will consult with the literature study on how chess games were used to improve the cognitive level of learners in Primary School. This will be followed by a review of the literature on the best practices for enhancing learner performance by teaching and learning mathematics through chess games.

Lastly, the study chapter outline will be laid out.

## 2.2 THEORETICAL FRAMEWORK

According to Chawira (2017), for quality academic writing, a scholar must choose a relevant theoretical framework and research design to guide the study. A theoretical framework is defined by Grant and Osanloo (2014) as the foundation from which all

knowledge is built for a research study, and this foundation serves as the “blueprint” for or the structure that underpins the entire study. The theoretical framework that was selected to guide this study was constructivism (Mogashoa, 2014.). Constructivist theory is a theory of knowledge that describes the nature of knowledge and how the learners are learning (Mogashoa, 2014). This study adopted the constructivist theory because the theory of constructivism is based on the idea that learners learn through constructing their new knowledge from prior knowledge (Baig, 2019; Bada & Olusegun, 2015; Pardjono, 2002). Constructivism is a learning model in psychology that describes how society might obtain knowledge and learn (Bada & Olusegun, 2015). The social constructivist theory guided this study because learners come across something new and reconcile it with their previous ideas and experiences (Bada & Olusegun, 2015). To do this, learners will be active participants in an independent environment; they will build their own meaning and knowledge through assumption, question, investigation, exploration, and imagination and assess what they already know during chess games (Baig, 2019; Bada & Olusegun, 2015). In addition, learners will reflect and make associations with prior knowledge of play to reach an understanding of chess games (Baig, 2019).

Constructivist theory is a theory where learners construct their own knowledge and meaning through interaction between their experiences and ideas. In other words, learners use their previous experiences as a foundation and build on it with new knowledge. Their background, as well as their latest knowledge, impacts how they can learn (Mogashoa, 2014). This theoretical framework is appropriate to this study because I had to understand how learners learn mathematics and how teachers teach mathematical concepts. In this case, it was important to understand the strategies of how learners learn and explore whether chess play may be used as a tool to learn different skills, such as problem-solving, which might improve their performance in mathematics. In addition, learners were given opportunities to interact with each other during the game of chess and construct their knowledge. For each player to make the first move on the chess board, they have to think of the possibilities of the first move, which is usually about twenty moves. Therefore, the learner has to use their previous knowledge to find the best way to build the new knowledge.

### 2.2.1 Interpretivist research paradigm

For any empirical research, the enquiry and research use an interpretive method based on Ryan's (2018:9) concept, which assumes that "truth and knowledge are subjective" because of differences in our culture and life experiences. Learning from the interpretive approach suggested by Berryman (2019:273), who believes that "social construction, language, shared consciousness, and other social interactions" are essential means for interpretive to invent facts. To achieve this goal, Berryman (2019:273) believes that for interpretive researchers to find answers to qualitative questions, they need to structure their research questions in a way that focuses on understanding "how and why." Interpretations are related to the philosophical position of idealism and combine different methods, including social constructivism, phenomenology, and hermeneutics, which reject objectivist views, meaning that meaning exists independently in the world.

The terms "interpretative research" and "qualitative research" are frequently interchanged despite the two concepts being fundamentally different. As a research paradigm, interpretive research is based on the premise that social reality is shaped by human experience and social backdrop, thereby making it well suited to research human behaviours related to the context of its sociocultural issues (Rehman & Alaharti, 2016). The interpretivist paradigm underpins this study. Data will be interpreted after they were presented from interviews and observations. Therefore, in this study, the researcher attempted to discuss how interpretivists can take a position on the influence of chess games on learners' performance in mathematics.

### 2.2.2 Constructivism and classroom practice

According to Gandhi (2020), there are several identifiable qualities which distinguish a constructivist classroom from a traditional classroom which are as namely, teaching and learning are learner-centred, learners are actively involved during the learning process; the environment is democratic, tasks are shared among the students, learners are intrinsically motivated, the teacher facilitates the process of learning by helping them to construct their own knowledge and learners interact with each other during learning. According to Mogashoa (2014), constructivism encourages problem-solving and collaboration to make meaningful knowledge.

Constructivism is a theory about teaching and learning which includes features such as culture, context, literacy, language, learners' interests and needs, personal experiences, and the application of knowledge (Mogashoa, 2014). There are different types of constructivism theories. Of these, social constructivism is related to this study and are expounded below.

#### *2.2.2.1 Constructivism learning*

Kelly (2012) suggests that social constructivism could be applied in the classroom using instructional methods such as case studies, research projects, problem-based learning, brainstorming, collaborative learning/group work, guided discovery learning, and simulations. The teacher could sometimes divide the class into groups or pair the students and then guide them by prompting, questioning and directing the groups or pairs to discover concepts or gather learning experiences according to the intended objectives. Teaching methods and classroom lesson delivery strategies are also important in mathematics. Chess play may be used as a tool where learners learn collaboratively against each other to promote the learning of mathematics to the learners. During chess games, the learners were grouped into pairs and played while the teacher directed learners to discover mathematics concepts. The learners obtain and improve different types of knowledge as they play chess. According to Bart (2014), chess play improves learners' intelligence, attention and reasoning abilities, thus developing many mathematical skills.

Handal (2009) claims that knowledge is not transferred from one individual to another in an educational environment as opposed to behaviourist models of teaching and learning (Candy, 1991, cited in Handal, 2009). During constructive learning, a learner acquires knowledge by using their previous experiences. In constructive learning, learners compare and contrast new situations by applying their intellectual schemata. In constructive learning, pupils learn mathematics by personally and socially building their knowledge.

According to Powell and Kalina (2009), there are two significant types of constructivism in the classroom: cognitive and social.

#### *2.2.2.2 Social constructivism*

Social constructivism theory upholds that knowledge develops due to social interaction and is not an individual possession but a shared experience (Mogashoa, 2014). Today's world is distinguished by social mobility, where teachers are anticipated to have various career paths and participate in re-skilling at different stages during their practice. Educators and institutions are gradually becoming more familiar with our philosophy and world being inconsistent with a culture of control in education, where teacher-designed content and practices are predominant. Jerome Bruner propounded the constructivism theory in 1966 (Olorode & Jimoh, 2016). Constructivism is the theory about knowledge and learning (Powell & Kalina, 2009). Thus, classrooms that follow "constructivist learning" will be more efficacious in preparing learners for lifelong learning (Kingir, Gok & Bozkir, 2013). The theory states that people construct their own understanding and knowledge of the world through experiencing things and reflecting on those experiences. This theory is based upon the principles of cognitive theory, hence sometimes referred to as cognitive constructivism.

Knowledge is socially constructed and co-constructed since it takes a group of people with language and culture to construct cognitive structures. The link here is that while the cognitive constructivist sees knowledge as what students construct by themselves based on the experiences they gather from their environment, the social constructivist sees knowledge as what students do in collaboration with other students, teachers, and peers. Social constructivism is a variety of cognitive constructivism that emphasizes the collaborative nature of learning under the guidance of a facilitator or in collaboration with other students. Vygotsky believed that lifelong development depends on social interaction and that social learning leads to cognitive development. In other words, all learning tasks (irrespective of the difficulty level) can be performed by learners under adult guidance or with peer collaboration. This theory helps to give a backup to establishing opportunities for students to collaborate with the teacher and peers in constructing knowledge and understanding. Kapur (2018) observed that the social construction of knowledge takes place in various ways and at different locations. It could be achieved through group discussion, teamwork, or any instructional interaction in an educational or training institution, social media forum, religious, or marketplace. As students interact

with people and the material and immaterial environment, they gain understanding and gather experience, which is needed to live successful and functional lives.

Kapur (2018) observed that the social construction of knowledge takes place in various ways and at different locations. It could be achieved through group discussion, teamwork, or any instructional interaction in an educational or training institution, social media forum, religious, or marketplace. In this study, students interact while playing chess. However, they interact individually during chess games. They use more thinking skills, further developing their cognitive thinking skills. As students interact with people and the material and immaterial environment, they gain understanding and gather experience, which is needed to live successful and functional lives.

Social constructivism is founded on the notion that information construction is a social activity rather than an individual one (Giannakopoulos, 2012). Vygotsky was the champion of this learning theory. Socio-cultural theory is the process whereby a learner learns through collaboration with others and the surroundings (De Valenzuela, 2010). The collaboration between the learner and the surroundings can be either a direct learning or a mediated learning process (Kozulin, 1998). According to Kozulin (1998), in direct learning, the learner can learn through practising the ideas in the subject by interacting with the environment.

In contrast, in mediated learning, the teacher or more knowledgeable person mediates between the learner and the environment. He further mentioned that knowledge is transmitted from a more knowledgeable person to a less knowledgeable person. Language and cultural products, such as reading ability, science and technology, affect media transmission. Vygotsky (1978) further states that a person brings about a change in surroundings, and surroundings bring about change to the individual. Kozulin (1998) claims that the socio-cultural theory is a perspective of learning theories that includes elements such as mediation, scaffolding, ZPD, and collaborative learning. The following briefly summarises mediation, scaffolding, ZPD and collaborative learning.

#### *2.2.2.3 Mediation*

According to Kozulin (1998), mediation is a process whereby the teacher adjudicates between the learner and the knowledge in a subject using the tools or teaching aids. Mediation can be in the form of psychological tools or semiotic tools (Kozulin, 1998). Psychological tools are used as aids in teaching learners to solve problems; these problems could not have been solved the same way without such tools (Kozulin, 1998). Semiotic tools are the devices that learners rely upon to make sense of learning in the classroom (Van der Westhuizen, 2012). Artefacts, symbols, or language are examples of tools that teachers can use to intervene between the learner and knowledge. In other words, the teacher engages between the learner and the environment to simplify the learning process (Kozulin, 1998). For this study, the teacher used chess play as a tool to teach the Grade 7 mathematics lessons to mediate between the knowledge and the learner.

#### *2.2.2.4 Scaffolding*

According to De Valenzuela (2010), scaffolding provides mediation, such as psychological or technical tools, in the learner's growth of higher mental functions. De Valenzuela (2010) further mentioned that scaffolding could be in a verbal or non-verbal form which is symbolic, including signals, eye looks and pauses. Scaffolding includes objects like artefacts on which the concept of a subject could have been challenging if the artefacts had not been used. Chess play will be a psychological tool in this study to mediate the learner's growth of higher mental functions. Chess play is a tool to improve the learner's problem-solving skills (Trinchero, 2013).

#### *2.2.2.5 Zone of Proximal Development (ZPD)*

Vygotsky presented the idea of ZPD to explain the man's conversion of cultural knowledge to individual knowledge (Giannakopoulos, 2012). ZPD is "the distance between the actual development levels as determined by independent problem-solving and the level of potential development as determined through problem-solving under adult guidance or in collaboration with more capable peers" (Vygotsky, 1978 cited in Greenes, 2009; Vygotsky, 1935 cited in Greenes, 2009; Wertsch, 2008). In other words, ZPD is the gap between what learners are gifted to do without

the support of a more knowledgeable person who can either be a teacher or a peer. For example, a learner can calculate a square's area but not a rhombus. Therefore, the teacher will close the gap between what the learners can do by themselves (calculating the area of a square) and what they cannot do by themselves (calculating the area of a rhombus).

For this study, chess play was used to close the ZPD gap of the learner through the teacher's assistance. ZPD offers a system of gaining awareness of learners' abilities and the training required to recognize their potential (Greenes, 2009). Therefore, chess play will be used by the teacher to assist the learners in recognising their potential and improving their problem-solving skills. Vygotsky (1978) announced the idea of ZPD to clarify the change of cultural knowledge to individual knowledge. According to ZPD theory, every individual holds certain information (basic knowledge) at a given time in life that supports them in completing tasks of a particular difficulty. They can complete tasks of higher difficulty levels and obtain more knowledge through association with a more knowledgeable person (area of a trapezium).

#### *2.2.2.6 Collaborative learning*

Collaborative learning is the process whereby the learners learn as a group through interaction with each other in a group (De Valenzuela, 2010). Through collaborative learning, learners learn from each other in a group (De Valenzuela, 2010). For example, suppose the learners are gathered to complete mathematics tasks irrespective of their intelligence. In that case, a learner who achieves well in mathematics can assist another learner struggling with the same concept (De Valenzuela, 2010).

This study used cognitive and social constructivism as a theoretical framework for the following reasons. It is important to note that both cognitive and constructive constructivism contain several similarities, namely the inquiry teaching methods and learners creating concepts built on existing knowledge that are relevant and meaningful (Powell & Kalina, 2009). Furthermore, cognitive and social constructivism value the inquiry or question-and-answer method. Similarly, both theories claim that directed forms of facilitation teaching are necessary as learners construct their own

ideas and understand what is being taught. Finally, cognitive and social constructivism agreed that the teacher's role was that of a facilitator, not a dictator or director (Powell & Kalina, 2009). In this study, learners played chess based on their previous game experiences. The chess coach only facilitated the process but did not dictate for the learners; in other words, the classroom was learner-centred.

Despite this, firstly, during cognitive constructivism, thinking precedes language, whereas in social constructivism, language precedes thinking. Secondly, in cognitive constructivism, ideas are constructed in individuals through a personal process, whereas in social constructivism, ideas are constructed through interaction with the teacher and other students (Powell & Kalina, 2009). In terms of learning theories, there are several essential differences between Piaget and Vygotsky. Piaget emphasises the thinking ability of individuals and how individuals recognise knowledge, while Vygotsky believed that social interaction, culture and language affect how the individual learns knowledge (Powell & Kalina, 2009). In addition, Piaget believed that the inner speech of reading to oneself is not a pre-requisite to thinking that one develops this learning process.

In contrast, Vygotsky believes inner speech is part of the critical learning and thinking process (Powell & Kalina, 2009). On the other hand, Piaget concentrates on a child's biological development, while Vygotsky focuses on a child's physical and cultural development. Finally, Piaget did not specify how mediation occurs during a child's development, whereas Vygotsky defines how mediation occurs during a child's development. Even though Piaget and Vygotsky differ, both concentrate on a child's social development and mediation.

As discussed above, it is clear that cognitive and social constructivism teaching approaches may be used by mathematics teachers simultaneously so that the learners can individually process what they have learned in a group, from their teachers or their peers. Both views of constructivism may be combined into a mathematics classroom and should be integrated for the best personal growth of the learners. mathematics teachers and learners may connect and transfer information to ensure that there is effective teaching and learning taking place in the classrooms. Constructivism should happen in all mathematics classes and every teaching activity so that authentic learning can occur. To achieve the goal of this study, the practices mentioned in both cognitive and social constructivism were applied during chess play

in mathematics lessons as follows: the learners were playing chess on their own, they had to decide about the moving of pawns, the chess coach was a passive participant who acted as a facilitator.

In contrast, learners were actively involved during the play. The learners were playing in groups, and they interacted with each other while learning the moves. Learners were self-motivated because they knew through play and wanted to win, but at the same time, they were learning new skills, such as problem-solving. I had a dialogue with the learners to ensure they constructed their knowledge by asking questions while playing chess.

#### *2.2.2.7 Vygotsky's socio-cultural theory*

Firstly, the mathematics teacher should allow learners to work in groups to learn from each other, i.e., peer group/peer tutoring. Secondly, mathematics teachers must be innovative when teaching mathematics concepts, e.g., using artefacts. As mentioned in the previous chapter, this study aimed to explore how chess games may influence learners' mathematics performance. Thirdly, the teacher must also use different methodologies to guide and support learners in constructing their own knowledge for effective teaching and learning of mathematics. Finally, the teacher must regularly give learners various assessments to close the ZPD gap. The learning theories mentioned above are essential in understanding the different ways of learning, which will advise on different teaching methodologies in mathematics. So far, this section has focused on the theoretical framework. The following section will discuss mathematics as one of the subjects in primary schools.

## 2.3 MATHEMATICS

In mathematics, signs and representations define mathematical, symmetrical and graphical relationships (CAPS, 2011). Furthermore, it is a social activity that involves observing, demonstrating, and examining patterns and quantitative interactions between physical and social phenomena and mathematical objects. mathematics helps children develop mental processes that improve their logical and critical thinking, accuracy and problem-solving skills that influence their decision-making.

### 2.3.1 The nature of mathematics

Mathematics is measured as a very brief and specific subject, allowing no room for various understandings or redundant words (Giannakopoulos, 2012). In other words, nearly every word or symbol in mathematical expression states a specific meaning. When one word or symbol is missed in mathematics, this might lead to miscalculation or misconception (Zevenbergen, 2011, cited in Giannakopoulos, 2012). Furthermore, mathematics is considered an absolute subject, which allows no room for debate in its entirety. According to Giannakopoulos (2012), the word mathematics entirety means mathematics is distinguished from other science subjects such as physics, chemistry and statistics since these subjects involve more absolute concepts, which can change if more information about them is revealed. Furthermore, several suggestions may be made about the nature and learning of mathematics (Giannakopoulos, 2012).

Firstly, mathematics is a challenging subject from the beginning, escalating as the learner moves from one grade to the next (Giannakopoulos, 2012). According to Giannakopoulos (2012), individuals who view mathematics as a complex subject of worthless symbols and abstract procedures avoid mathematics because they do not risk being considered stupid. Meanwhile, some students choose mathematics for enjoyment, and enjoyment is associated with skill (Rodd, 2002, cited in Giannakopoulos, 2012).

Secondly, mathematics may be understood to represent internal sound relationships among concepts, although still experimental, generalisations based upon experiences (Giannakopoulos, 2012). Mathematics is a subject which needs a pragmatic approach and also emphasises experimentation (Giannakopoulos, 2012).

Thirdly, mathematics is viewed by some learners as a subject of worthless abstract symbols which can be learned by memorising abstract procedures and processes and copying them. Some learners and teachers hold these perceptions. Therefore, many learners subsequently avoid taking mathematics as a subject (Giannakopoulos, 2012); this is evident in the literature, and engineering and science fields have a low enrolment of students (Giannakopoulos, 2012).

Finally, according to Giannakopoulos (2012), the absoluteness of mathematics, which is constant, precise and universal, needs a specific way of teaching which

depends on culture. For example, to teach a child from any part of the world that 3+2=5 differs from culture to culture, teachers should be aware of this and modify the teaching of mathematics accordingly (Giannakiopoulos, 2012). For this chapter, having discussed the nature of mathematics, I will now move on to deliberate the teaching of mathematics.

### 2.3.2 Teaching of mathematics

Mathematics education is a critical part of the curriculum for learners internationally (Linder, Powers-Costello & Stegelin, 2011). A significant goal of mathematics education is for learners to realize and appreciate that mathematics is not only a powerful tool for understanding the world but also a powerful tool for discovering the world (Silver, Kilpatrick & Schlesinger, 1990, cited in Greenes, 2009).

### 2.3.3 Factors affecting the learning of mathematics

According to Giannakopoulos (2012), several factors affect mathematics learning. These factors include working memory, attitudes towards mathematics, mathematics self-concept, self-efficacy, student attitude and background, curriculum and instruction, home and peer environment, teacher practices, socio-economic status, gender and problem-solving. The aim of this study was to look into the influence of chess games on the performance of learners in mathematics. These factors are discussed in the following section.

#### *2.3.3.1 Attitude towards mathematics*

Students' achievement in math is significantly influenced by their attitudes. Students' attitudes towards mathematics affected their learning process and academic performance (Heilbronner, 2013).

#### *2.3.3.2 Environment, gender and problem-solving*

Gender refers to the social construction of diverse physical, biological, mental and behavioural characteristics relating to differences between the male and female sex.

It is a social and cultural construction of roles, access to and control over resources between men and women, or boys and girls in society (Akena, 2020; Fogliati & Bussey, 2013; Chilisa & Ntseane, 2010; Fennell & Arnot, 2008). Researchers such as Apriliyanto and Saputro (2018), Davadas and Lay (2017), Kent (2017), and Mccarthy, Sithole, Mccarthy, Cho and Gyan (2016) emphasized that for students to develop their abilities and establish an in-depth understanding of mathematical knowledge and skills, mathematics learning practices must concentrate on classroom teacher-students, students-teacher, and student-student interactions.

In Ghana, Letsoalo (2017) reviewed the literature on gender and mathematics achievement in WASSCE up to and including 2017 and came to three conclusions: boys in secondary schools perform slightly better than girls in secondary schools on tests of mathematical reasoning (mainly solving word problems); (2) boys and girls perform similarly on tests of algebra and basic mathematical knowledge; (3) girls occasionally outperform boys on tests of numeracy. In a study of student performance in mathematics among Senior High School students in the Western region, Marginson and Dang (2017) employed an exploratory design involving 68 students and 12 teachers to assess the factors that accounted for the poor performance of students in mathematics. They concluded that most factors that predicted students' performance were from the school environment and could be addressed by the school management. While their study investigated the factors affecting students' performance in mathematics, they did not pay specific attention to the factors affecting female students' mathematics performance.

Another study shows that women achieve better grades in mathematics than men (Matteucci & Mignani, 2021). Some recent studies have shown that gender differences in mathematics education seem to be narrowing in many countries. However, studies show that as students reach higher grades, gender differences favour male performance in mathematics (Matteucci & Mignani, 2021). Boys attribute their success in mathematics more to stable factors, for example, task difficulty or ability, in contrast to girls, who attribute more to unstable factors such as effort, luck, and a good teacher (Breda & Napp, 2019). Copper, Evans and Law (2020) examined the differences in attributions between high-achieving boys and girls for success and failure in general academic subjects, language skills, science, and mathematics. Robert and Owan (2019) also investigated the causes of poor

academic performance by Senior High School female students in Columbus. They found that students' socioeconomic background was statistically significant in explaining their performances. The findings of a study conducted by Ali et al. (2010) showed that the problem-solving method could help students perform better in mathematics than those taught by the traditional method.

The methods exposed students to taking responsibility for their own work, with the teacher acting as the facilitator. Chess playing during mathematics lessons may also positively affect problem-solving, concentration, and self-discipline (Sigirtmac, 2011).

## 2.4 CHESS

Chess is an economic mind game requiring extremely complex mental skills (Franke, Gränsmark, Agricola, Schühle, Rommel, Sebastian, Balló, Gorbulev, Gerdes, Frank Ruckes et al., 2017; Hawkins, 1998). According to Joseph et al. (2016), chess is a board game of strategy played by two people in which the king's enemy is directly attacked, leading to a checkmate. Chess is a global learning experience for learners of varying talents and backgrounds (Williams, 2014). Chess is a game of two performers with 16 pieces each on a board of 64 squares (Hawkins, 1998).

The game is played on an 8x8 square board. According to Scholtz, Niesch, Steffen, Ernst, Loeffler, Witruk and Schwarz (2008), each player in chess uses procedures, creativity and eagerness during the game. Scholtz et al. (2008) mentioned that the basis of chess lessons begins with understanding the board and the pieces, the rules of movement and the value of each piece on the chess board.

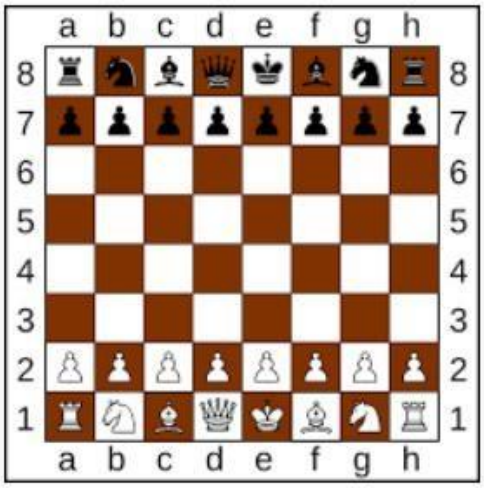



***Figure 2.1: Chessboard (Wikimedia Commons, 2023)***

Each chess game presents itself with new problems to solve. Playing chess has been closely connected with critical thinking. Playing chess improves the individual's critical thinking skills (Berkley, 2012). The researchers and chess players could claim that every move in chess involves the player using several essential critical thinking skills (Berkley, 2012).

### 2.4.1 Origin of chess

Chess was developed more than 1500 years ago in India and was initially known as Chaturanga (Bhatta, 2003). According to Joseph et al. (2016), chess originated after the king requested his wise men to create a strategy to instil children of the royal family to become better thinkers and better generals on the battlefield. When a king in India was tired of games played at the time, he ordered a mathematician who lived in his empire to develop a new game. After several attempts to develop a new game, the poor mathematician developed a new game called Chaturanga. In this game, the king led two armies and commanded the army to defeat the opponents by capturing their king. The king was impressed with the game and offered to compensate the poor mathematician. However, the mathematician only requested one grain of rice for the first square of the board, two grains for the second, four grains for the third, and so on, which were doubled for each of the 64 squares of the game board. The king was initially confused by such a request, but later, he realised that the whole kingdom's rice supply was exhausted even before the $30^{th}$ square was reached. As a result, the king offered the poor mathematician the position of his topmost advisor because he regarded him as a genius. Chaturanga was later referred to as chess. Chess is one of the ancient games in the history of man and is the one which has been exposed to the highest amount of literacy attention (Kierman, 1957, cited in Berkley, 2012). Chess has gained a reputation for many eras through literacy attention (Garcia, 1990, cited in Berkley, 2012).

Unfortunately, there is not much literature about the origin of chess. Most books are concerned about how chess is played rather than the history of chess (Kiernan, 1957, cited in Berkley, 2012. According to Berkley (2012), Kierman's work on the history of world-wide chess is the only study focused on the history of chess. Ever since the sixth century, the rules and movements of chess pieces have been the

same (Celone, 1999). The chess pieces are Rook, Knight, Pawn, Queen, King and Bishop (Berkley, 2012). The chess pieces used during competitions are named after a champion chess player in England called Howard Staunton (Berkley, 2012).

Adolf Anderssen (the mathematician) won the first chess tournament in London in 1851. These tournaments include professional chess players who participate and play for money (Berkley, 2012). The best specialists in chess during the tournaments regularly had to put their full attention into chess. As a result, giving a lot of time to family or putting time into another career was challenging. According to Kiernan (1957, cited in Berkley, 2012), chess did not obtain much spectator interest like other games, such as football, since people did not find chess exciting. Nevertheless, it can be disputed that chess is an exciting, demanding and unpredictable game (Celone, 1999). The unpredictability lends itself to a wide range of opportunities obtainable through playing chess (Berkley, 2012).

The game of chess was valued and appreciated and became a popular national sport in Russia (Celone, 1999). Since the 1940s, the Russians have conquered the chess world while other countries, such as Britain, are close behind (Celone, 1999).

### 2.4.2 Connection between chess and problem-solving skills

Teachers consider applying the game of chess as an instructional approach to arouse intellectual processes such as memory and focus (Krogius, 1972, cited in Gliga & Flesner, 2014) or to reinforce skills such as problem identification, problem-solving, planning strategies for learners (Storey, 2000 cited in Gliga & Flesner, 2014).

Research by various Russian researchers such as Dvoryatkina, Karapetyan, Dallakyan, Rozanova and Smirnov (2019), Ignatiev (2018), Brestel (2011), and Glukhova (2008), and many international researchers such as Sala et al. (2017), Sala and Gobet (2017), Burgoyne, Sala, Goblet, Macnamara, Campitelli and Hambrick (2016), and Kazemi (2012); established the relationship between students' cognitive abilities and their ability to play chess. Furthermore, Sala et al. (2017) and Burján (2016) claim that chess improves students' mathematical abilities in primary and secondary schools. For instance, they empirically proved that chess significantly influences the formation of a wide range of cognitive abilities, such as attention,

concentration, planning, memory, logical thinking, and spatial imagination. The authors consider teaching chess an effective educational tool that has a positive cognitive effect on children's mastery of math, both in the short and long term.

Therefore, the educational aspect of the integration implies improving the content, forms, and methods of education aimed at developing students' intellectual and cognitive abilities. Mathematical problem-solving skills improve by learning many problem-solving strategies which relevant mathematical examples meet (Dvoryatkina et al., 2019). Some educational aspects devoted to solving mathematical problems on a chessboard were investigated in various studies conducted by Poloudin (2017), Gik (2013), Gardner (1959) and Okunev (1935). Teachers consider applying the game of chess as an instructional approach to arouse intellectual processes such as memory and focus (Krogius, 1972, cited in Gliga & Flesner, 2014) or to reinforce skills such as problem identification, problem-solving, planning strategies for learners (Storey, 2000 cited in Gliga & Flesner, 2014).

### 2.4.3 Chess and mathematics

There is a strong connection between chess and mathematics (Hong, 2007; Milat, 2004; Schiff, 1991). Smith (1998) prepared a quasi-experiment study with an experimental group of African-American high school juniors and seniors trained in chess instruction for 18 hours. The experimental group had eleven females and eight males, while the control group had ten males and ten females. According to Smith (1998), the treatment group scored significantly higher than the control group on post-test measures of mathematical achievement, field dependence/independence and spatial visualisation. All the students in the study were defined as field-dependent students. Field dependence students are those who view conditions from a universal viewpoint, are people-centred, enjoy group work and use intuition and randomness, while field independence students are those who view conditions from a logical perspective, support individual work, succeed in analytical and critical thinking, and pays close attention to details (Smith, 1998). The commonality in Smith’s and this current study is that learners have little or no previous chess knowledge, and chess instruction emphasises problem-solving skills. Smith (1998)

includes the textbooks used for the study but does not indicate the reasons for choosing such textbooks (Berkley, 2012).

To date, many studies have examined the positive effects of chess on children's mathematical ability (Sala, Gorini & Pravettoni, 2015; Kazemi, Yektayar & Abad, 2012; Trinchero, 2013; Barrett & Fish, 2011). Barrett and Fish (2011) examined the effectiveness of chess training on children's mathematical development in special care centres using the Texas Assessment of Knowledge and Skills (TAKS) program, whose results showed that the chess training group performed better in mathematics than the control group.

Sala et al. (2015) and Trinchero (2013) focused on studying the effects of chess training on the mathematical problem-solving ability in an elementary school; compared with the control group, the results showed systematic superiority of experimental group performance (which was trained and practised in playing chess). Their results showed that chess training was more effective than conventional mathematical training. However, their subsequent follow-up showed that these effects are not generally transmitted to out-of-school environments. However, Poston and Vandenkieboom (2019) have reported a moderate to strong impact of chess on students' math and reading ability; in their study, children who participated professionally in chess tournaments were compared to children who were only in clubs. They were entertained by the game, learning mathematics and reading better, and the effects lasted longer.

According to Sigirtmac (2012), chess positively affects planning skills, cognitive development, problem-solving, reading performance, concentration, self-discipline, and mathematics. Williams (2014) concurs with Sigirtmac (2012) by demonstrating that chess reduces behavioural problems and increases learners' academic achievement. Sadik (2006, in Sigirtmac, 2012) also found that the performance of basic operations of fourth and fifth-grade mathematics learners who knew how to play chess was higher than their counterparts who had never played chess. According to Trinchero (2013), chess is one of the most common games associated with concepts such as intelligence, strategy, and reasoning. Many researchers, such as Sala et al. (2015), Kazemi et al. (2012), and also Trinchero (2012), and Trinchero and Sala (2016), have claimed that chess training increases children's mathematical skills because playing chess helps to form the thinking of the learners mostly when

facing the mathematical problems. Trinchero and Sala (2016) have indicated that chess training corresponds with mathematical problem-solving ability because children must be able to identify and understand a situation, study different ways to solve the problem, choose the best decision and monitor its consequences when encountering mathematical problems. The benefits of chess in learner achievement are also evident in blended learning, as indicated by Trinchero (2013). According to Trinchero (2013), intervention of blended chess training can improve learner achievement on the OECD-Pisa Mathematics scale.

Game-based learning is a method for obtaining new concepts and skills through digital and non-digital games (Grace, 2019). Playing games in education can foster notable improvements in learning and education outcomes (Kula, 2021; Syafii, Kusnawan & Syukroni, 2020). According to Boctor (2013), the process by which the game-based learning approach supports learning comprises two steps: First, games can motivate students to combine knowledge from various disciplines and utilize it in decision-making processes, and second, students can test how game outcomes change based on the choices and decisions they make. It also allows students to communicate with other participants and discuss game-related moves; this increases coordination, improving social association skills. This is related to this study because learners can apply knowledge gained during chess play to solving mathematical problems.

### 2.4.4 Benefits of chess

Much literature has been published on the benefits of chess (Joseph et al., 2016; Trinchero, 2013; Kazemi et al., 2012).

Furthermore, Barret and Fish (2011) have supported the view that chess intervention during mathematics teaching has a positive cognitive effect on regular school learners. Besides, the use of chess during mathematics lessons improves achievement for learners who receive special education services (Barret & Fish, 2011), benefit children who are at rural schools (Joseph et al., 2016), improve novice children (Gliga & Flesner, 2014), provide evidence for data-driven decision making by educational leaders (Barret & Fish, 2011). Hunt and Cangemi (2014) assert that chess games have a positive effect on mental development (Joseph et al., 2016;

Sigirtmac, 2012), and chess practice can make people more intelligent (Trinchero & Sala, 2016).

Chess can increase the problem-solving skills of mathematics learners (Barret & Fish, 2011). Moreover, Celone (1999) also notes that chess can be used to teach problem-solving and abstract reasoning. Chess is not only valuable for the academically gifted children but also for disabled and hyperactive children, and the progress in intellectual abilities would be significant in educational settings (Berkley, 2012).

Despite many researchers indicating the benefits of chess, as shown in the section above, chess has received less consideration than it deserves as an educational instrument that can benefit teachers and policymakers to advance learners' academic performance (Williams, 2014). Several countries internationally have applied chess play within their curriculum because they recognise the benefits of chess (Williams, 2014); however, there is still a lack of chess play in mathematics curricula to advance problem-solving skills in South African primary schools. Currently, chess plays a role in the school curriculum, which may have resulted in strong players in Russia (Berkley, 2012).

However, the researcher has observed that there is inconsistency with the argument in the above paragraph because even though there is a lot of research on the advantages of chess, there are also disadvantages of chess, namely, sometimes chess games need a lot of time to complete and only two people can play chess on a single board at a time. Finally, more practice is required to master chess.

Chess games take a lot of time. Although the Department of Education encourages schools to allow their learners to play chess, the CAPS policy document does not indicate that chess can be allocated during regular school teaching and learning time slots. Hence, schools that have chess let learners play these games after hours.

Debate continues about the best strategies for managing chess practice to stimulate the application of problem-solving skills in other domains, such as mathematics (Trinchero & Sala, 2016). Chess is primarily an exercise of logic and can stimulate creativity among students (Celone, 1999). Chess is exceptional from other games since it is a battle between two people and a struggle of the mind (Celone, 1999).

Chess can bring about the aspiration to discover and enter the uttermost reaches of the imagination, which are also common characteristics of critical thinking (Berkley, 2012).

## 2.5 CHAPTER SUMMARY

Chapter 2 set the foundation for Chapter 3, where general learning theories were deliberated and discussed the relationship between mathematics, problem-solving and chess play. Firstly, this chapter discussed the theoretical framework (learning theories) and educational implications. Some of the different learning theories were discussed, taking into account constructivism, which informs this study.

Social constructivism and cognitive constructivism were critically reflected; however, for this study, it was acknowledged that social constructivism is a good theory to use in mathematics classes. Furthermore, Piaget and Vygotsky's leaning theories were critically reflected. Secondly, the following section discussed mathematics, which included the nature of mathematics, the teaching of mathematics and factors affecting the learning of mathematics. In this section, it was argued that teaching mathematics is different from teaching other subjects and requires a different approach to teaching compared to teaching other subjects. Thirdly, problem-solving was defined, and the types of problem-solving, factors influencing problem-solving, implementation of problem-solving skills for Senior Phase mathematics learners and approaches to problem-solving were discussed. Poyla's general four-step plan in problem-solving approach was deliberated. In this section, error analysis was emphasised to prevent the re-occurrence of errors in unsuccessful problem-solving. SIP was used as an example of the Free State Department of Education (FSDoE) to improve school mathematics. The importance of successful and unsuccessful problem-solving was also debated.

Finally, a discussion of chess followed, including the definition and origin of chess, chess and mathematics, chess and education, and the benefits of chess. In this section, it was highlighted that there are several weaknesses of chess play even though chess has more benefits in mathematics classrooms. The connection between chess and problem-solving skills was also discussed. In conclusion, Chapter 3 will focus on research design and methods. This chapter will discuss the

research design and methods in detail, including the research methodology, location, data collection and generation methods, population and sampling, and data processing.

# CHAPTER 3
# RESEARCH METHODOLOGY

## 3.1 INTRODUCTION

This chapter briefly focused on the research design and methodology used in this study. Research design and methodology describe the research process, and the tools and procedures used in collecting the data (Johnson & Christensen, 2004). In subsequent sections, the research approach and design, research paradigm, sample and population, participants, data collection, data collection procedures, data analysis and methodological norms such as credibility, trustworthiness and ethical considerations are discussed.

## 3.2 QUALITATIVE RESEARCH APPROACH

This study is underpinned by the qualitative research method used to collect, analyse and interpret the data (Ary et al., 2010). A qualitative research approach within an interpretive paradigm was employed in the collection of data in an attempt to answer the research question: What is the impact of the game of chess on the mathematical understanding of Senior Phase mathematics learners? The interpretive research paradigm provides a rich descriptive interpretation targeted to understanding a phenomenon, a process or a particular understanding from the viewpoint of those involved (Ary et al., 2010).

Qualitative research includes developing interview questions and processes, data collected from participants' settings, inductive data analysis built from particulars to general themes and the researcher's interpretation of the meaning of data (Creswell & Creswell, 2018). According to Creswell and Creswell (2018:281), the historical origin of qualitative research comes from anthropology, sociology, humanities and evaluation. Data in this study were collected from one of the primary schools where Grade 7 learners played chess and did mathematics, indicating that the information collected related directly to the learners and observed their behaviour and actions within their environment (Creswell & Creswell, 2018). The behaviour of the learners was observed, and the learners were interviewed. Creswell and Creswell (2018)

assert that multiple data sources, such as interviews, observation sheets, and audio-visual information, can gather information from various sources rather than rely on one data source.

This method was appropriate because qualitative mode was used to collect rich participant data from the phenomenon under study (Yilmaz, 2013; Ary, Jacobs, Sorenson & Razavieh, 2010). Qualitative research prompts for an in-depth understanding of the relationship between chess games and performance will be completed in detail (Ary et al., 2010). Qualitative methods were used to obtain rich data from the participants of this study (Yilmaz, 2013).

### 3.2.1 Applications for the qualitative approach in this study

To remain unbiased, the researcher was neutral as an observer while learners were playing chess (Creswell & Creswell, 2018).

During the data collection process in this study, multiple data sources, such as focus group interviews, observation sheets, and audio-visual information, were used to gather information rather than relying on a single data source. Face-to-face interaction took place with the learners through interviews, and their actions and behaviour while playing chess were observed. I worked inductively to build patterns, categories and themes by classifying the data into abstract information units. I also worked deductively by looking back at the data from the themes to decide if more evidence will support each theme or if additional information need to be gathered (Creswell & Creswell, 2018).

## 3.3 RESEARCH DESIGN

A research design is a plan or strategy that moves from the underlying theoretical assumptions to identify the selection of participants, the data-gathering methods to be used, and the data analysis for either quantitative or qualitative study (Maree, 2016; Creswell, 2012). Research design in the investigation within the qualitative method approach offers the direction for processes during a research study (Creswell & Creswell, 2018)

Majid (2017) explains the research design as a consequence of the research question, objectives, and phenomena of interest, population, and sampling strategies. A satisfactory design is a critical factor for carrying out a meaningful study or research (Chivanga, 2018). As a teacher in the curriculum directorate and researcher, I am more concerned with how chess game influences the understanding of mathematical concepts. That is why I have chosen a design I believe was satisfactory for conducting a suitable and meaningful study.

Maree (2014) discusses the five approaches to qualitative research designs. These are narrative studies/research, phenomenology, grounded theory ethnography, and case study. For this study, only phenomenology will be discussed, as it is the relevant qualitative research design that this study adopted.

A phenomenological design was used in this study. Phenomenology is not just a name of philosophical perspective, but also a source for questioning the meaning of life as we live it and the nature of responsibility of personal actions and decisions (Wilson, 2015). The study investigated individuals' perceptions, perspectives, and understandings to derive the meaning of a particular phenomenon (Thomas, 2017). Phenomenological is a philosophic framework and research approach. Its primary position is that the most basic truths are accessible only through inner subjectivity, and personal integrity to environment. It is an interpretive approach considering life's ordinary senses and experiences (Alvesson & Sköldberg, 2017). Therefore, this study adopted a phenomenological research design. Originating deeply in philosophical perspectives of consciousness (Maree, 2014:77), phenomenology is regarded as having its origins in the works of Edmund Husserl (1859-1938). It was extended in the works and writings of Martin Heidegger, a German philosopher (1889-1976), who is best known for contributions to phenomenology, hermeneutics, and existentialism (Wheeler, 2011).

Pernecky (2016) gives a view that what we come across in everyday experiences constitutes the social reality that we live in our thinking and how we make sense of them. This research design (phenomenology) attempts to describe and explain the fundamental structures of these human behaviours (Brinkmann & Kvale, 2017). Qualitative research allows room for interpretation of data collected.

During the data analysis process or stage, employing a phenomenological design, Creswell advanced the following procedures:

a) The researcher must describe their own experiences with the phenomenon of study as a way of trying to identify personal judgements and biases so that they do not contaminate the process of analysis.
b) The researcher advances with the parallelization of data generated. This is the process wherein the researcher files each pertinent quote of the studied phenomenon and gives them the same value regarding the group's pronouncements. This starts the textual descriptions: what are the participants saying? What are the pertinent topics communicated by the research participants?
c) The researcher organizes the pertinent themes into meaningful components.
d) The researcher puts in writing the literal account and involves precise excerpts.
e) The researcher puts down structural images.
f) Lastly, based on textual and structural analysis, the researcher classifies the phenomenon's essentials: the usual recurring segments in each research respondent.

The principal aim of phenomenology is to apprehend, as direct as possible, the way a phenomenon was experienced by participants (Creswell & Poth, 2018). That is why I could employ this design to narrate how participants implement chess games to understand mathematical concepts in senior phase schools. What makes a phenomenon interpretative, according to Salamon (2018), is that it is more inter-subjective.

This design made me concentrate specifically on each participant’s perspectives, attitudes, experiences, and beliefs to evoke their lived experiences on managing the implementation of the mathematics curriculum in schools. This research design enlightened the study’s population, which was relevant for generating the wanted data and addressing the main research question. The use of ontologies creates a bridging mechanism, whereby validates to ensure that relevant and useful information is collected (Chowdhurry, 2014).

## 3.4 PHILOSOPHICAL PARADIGM USED IN THIS STUDY

This section unfolds the philosophical paradigm proposed in the study, a definition and history of that paradigm and how the paradigm shaped the approach to this study.

The constructivist theory and were used to inform and guide this study (Piaget, 1969). The constructivist paradigm was chosen for this study because the theory of constructivism is based on the idea that learners learn through constructing their new knowledge from prior knowledge (Baig, 2019; Bada & Olusegun, 2015; Pardjono, 2002). In other words, learners learn by connecting further information with what they already know (Bada & Olusegun, 2015).

## 3.5 DATA COLLECTION

According to Merriam (2018), qualitative research aims to generate vivid, multi-dimensional facts that offer an initial outline of investigation methods and strategy for inquiry. The application of research methods and techniques depends on the aims and objectives of the study, the nature of the phenomenon being investigated and the researcher's underlying constructivist theory or expectations. Methodology subsequently refers to how we approach problems and seek answers to them, and it helps to justify the purpose of social research (Thomas, 2017; Taylor & Medina, 2014; Houghton, Casey, Shaw & Murphy, 2013).

This section describes the procedures used to gather the data in this project. Data collection aims to answer the research question of this study. The data collection process includes the data collection procedure, population and sampling, data participants, instruments, data collection instruments, data collection procedure, the study context and data analysis (Merriam, 2018).

For the purpose of study to be achieved, face-to-face focus group interviews, observation when learners play chess, and video recordings were used to collect the data to check whether there was any improvement in learners in mathematics.

This process is discussed in the section below.

### 3.5.1 Population and sampling

This study used purposive sampling as a procedure that reinforces as it is grounded on the principles of non-randomised theory (Maree, 2016). In research, the small observed group taken from a larger population according to specific procedures is known as a sample. In contrast, the larger group about which results are generalised is known as the population (Johnson & Christensen, 2004). The first sampling step in this study was identifying the target population (Ary et al., 2010). In this case, all the Primary School learners in the Free State province were the target population. Once the population was purposively identified in this study, then the sample was recognised. The purposive sampling method does not use random selection of population components. It would, therefore, be risky for a researcher to draw essential inferences about the population (Maree, 2016; Johnson & Christensen, 2004).

Purposive sampling is more convenient for qualitative research (Maree, 2016). Hence, the researcher chose the purposive sampling method to strengthen this study. Grade 7 primary school learners were selected to participate in this study. The aim was to get rich data to determine the impact of chess games on understanding of mathematical concepts of senior phase learners (Henning, Van Rensburg & Smit, 2004). Secondly, the researcher had a continuing relationship with the school, and finally, the school was prepared to accommodate the research process and assign the necessary class time to this research (Johnston, 2010).

### 3.5.2 Participants

According to Creswell (2014), one way to conclude a sample size is to select adequate participants for the statistical processes a researcher plans to use. For this study, the participants were selected from Grade 7 learners from one of the primary schools in Motheo district in the Free State Province. The study was conducted at this school with purposively selected Grade 7 learners who are already chess players. In this school, most learners are from various social, economic and cultural backgrounds and are taught mathematics by the same teacher. The school is one of the previously disadvantaged schools categorised to be on Quintile 2 according to

the Provincial Department of Education ranking. The Language of Learning and Teaching (LoLT) is English, while the learners' home language is Sesotho.

Even though the consent forms were given to the deputy to the parents of Grade 7 learners, the researcher discovered that the deputy gave them to all Grade 6 and 7 learners who were doing chess. According to the report from the Deputy principal 58 learners were playing chess in the school. Therefore 58 consent forms were issued for the learners. Then 29 learners did not return the consent forms. Only 29 consent forms were returned. 29 consent forms were from grade 6 and grade 7 learners. Out of 29 consent forms received there were 12 grade 6 learners as well as 17 grade 7 learners. Since this study focussed on grade 7 learners, then grade 6 learners were not part of this study. Only 17 grade 7 learners were participants in this study. The ages of participants ranged from 12 years to 15 years. Out of 17 participants 11 were females while 7 were males. Out of 17 participants they were divided into three small groups. Two groups had 6 learners each while the other group had 5 learners. The school also selected for this study because learners were already exposed to chess games even before the administering of this research. This project used observation sheets, video recordings and focus group interviews to collect qualitative data.

### 3.5.3 Data collection procedure

The duration of data collection of this study was approximately three weeks. The process of data collection in this study involved more than simply gathering data but contains five steps which were namely, steps for determining participants to study, finding approval needed from several individuals and organisations, considering what type of data to collect from several sources to the study, finding and choosing instruments to use that will clear useful data for the study and finally administering the data collection process for the study (Creswell, 2014). These steps informed this study and are summarised in the section below. The first step is to purposively select participants to determine who the units of analysis are (Creswell, 2014). Unit analysis is the level the data needs to be gathered (Creswell, 2014). The purposively selected school is a public school located in a township for this study because it is one of the primary schools in which one of their classes performed below the 50

percentiles in mathematics during 2019 in the province. The purposefully selected Grade 7 learners were participants who assisted me in getting responses to this study (Creswell & Creswell, 2018). Grade 7 learners who were already playing the game of chess was requested to participate in this study, where face-to-face interviews, observations, and recorded videos were used as data collection instruments. The nature and actions of the learners when playing chess were observed as part of the data collection process.

The Chess coaches held chess lessons every afternoon from half past two (14:30) to Four o'clock (16:00) except Fridays after school. Chess coaches are employed at the same school. The investigator made an appointment with the principal for collecting the data of this study. The meeting intended to discuss the purpose of this study, participants, consent forms and the date and time for data collection. After the principal gave permission to conduct this study, she referred the researcher to the Deputy Principal. Then the Deputy introduced the chess coaches to the researcher. The Deputy principal was requested to issue the consent forms to the learners and collect them before the actual data collection date. On the data collection date, the researcher arrived at the school 30 minutes before the actual time. It was just after school, and the learners were playing outside their classroom. Even though the Deputy principal were provided with parental consent forms before the data collection date, only to find that the participants did not fill in the consent forms from parents as expected. Through the permission of the principal, the researcher had to reschedule another date for parents to complete consent forms to allow their children to participate in this study. The researcher dispatched 58 consent forms in total to the learners.

Upon the researcher's arrival at this school for the second date, the venue was not readily prepared and had to be cleaned first. At the beginning of the data collection process, the researcher was introduced by the chess coaches to the learners who were participants in this study. Chess coaches did not participate in this study but assisted with controlling learners and distributing chess boards and chess pieces. Chess coaches and the deputy principal handed over the completed consent forms to the researcher. Only 17 grade 7 parents completed the consent forms. In addition, twelve Grade 6 learners were also present and willing to participate in this study. Their parents had already filled in their consent forms. They agreed that their

children should participate in this study. In total, there were 29 participants whose parents completed the consent forms. However, grade 6 learners were not used in this report since they do not form part of this study. The participants came from different classes of grade 7 in which the same coaches evenly rotated; thus, any coaching provided to the participants was the same even though learners came from other classes.

#### *3.5.3.1 Focus Group Interviews*

An interview is a two-way discussion in which the interviewer asks participants questions to gather data and learn about participants' thoughts, opinions and behaviours (Maree, 2016). The semi-structured interviews (Appendix I) were conducted with Grade 7 learners after playing chess games. Semi-structured interviews were important in this study because they verified and validated data obtained from observations and recordings administered (Maree, 2016). The interview protocol was handed to the chess coach and the principal before the formal interview (see Appendix I). As the accounting officer of the school, this allowed the principal to be aware of the types of questions to be asked of the learners for ethical purposes. Furthermore, the questions which the principal needed clarification on were explained.

The learner interviews were conducted in the school hall since the school lacks facilities; this was also done so as not to affect the normal smooth running of the school. The tape recorders and video machine were tested two days ago and just before the interview to ensure they were still in good working condition.

##### *3.5.3.1.1 The process during focus group interviews*

For this study's qualitative approach, focus group interviews were completed with learners towards the end of the data collection process. Two groups of 6 learners each and also one group with 5 learners were interviewed with the assistance of a chess coach to accomplish a focus group interview. During data collection process all groups were audio-recorded so that issues that may arise from the data collection process may be clarified and to facilitate the interpretation of the verbal responses of

the learners (Patton, 1990 cited in Yilmaz, 2013). Audio recording was used to keep the data safe for presentation and analysis purpose.

The interviews with the learners took approximately 30 minutes. Upon completion of the interviews, the written record (transcripts) of what was debated during interviews was transcribed on the same day while it was still fresh in the memory for data analysis. A copy of the interview program and researcher contact details were given to each participant for any enquiries that may arise as a result of the process.

#### *3.5.3.1.2 Observations*

Observation was the other method of data collection in this study. The learners were observed as they were playing in chess games. The researcher observed how learners put chess pieces on the chess board and how each pair started to play. The researcher also observed how a learner uses strategies to engage their opponent. The learner observation sheet (Appendix K) was used to capture elements of engagement, namely, the affective, the behavioural, and the cognitive elements. The observation sheet was taken from Tachie and Ramathe (2022).

## 3.6 DATA ANALYSIS

Qualitative analysis is a ‘continuous search for patterns and explication of their meanings’ through progressive focusing, reflexive iteration and grounded interpretation. It aims to gather rich data on the investigation of phenomena and link them to literature (Punch & Oancea, 2014). The qualitative data, including the transcriptions of all interviewees in this study, were segmented into significant elements and coded with precise descriptions and meanings. The topics of the interviews were grouped into themes, categories, and codes. Finally, the literature review was an essential additional system to contextualize the themes to understand the findings better.

All data recorded through digital means were transcribed (Maree, 2016). Audio tapes assisted the researcher in transcribing them verbatim, i.e., rewritten word-for-word. The researcher arranged the data so the analysis was handled without flaws. All data were compared and organised into themes. Data were, therefore, sorted and

typed. The researcher read, reread, and listened to audio recordings of the data collected to interpret the participants' responses correctly. This process, called “memoir” (Silverman, 2016), helped to write down any impressions the researcher got when going through the data collected. The primary analytic method of the interpretative researcher is constant comparison (Thomas, 2017). It is otherwise referred to as a continuous comparative method. It involves going through your data again and again (at the constant bit) and comparing each element phrase, sentence or paragraph – with all of the other aspects (the comparative bit) (Thomas, 2017).

During this process, the researcher constantly compared and marked the data with codes – abbreviations, pseudonyms, marks, and colour names; this assisted in describing their important facets. The themes created were captured and summarised. As Thomas (2017) interchangeably uses the words, these themes or categories were crucial building blocks for data analysis. As the interpretative approach was employed in this study, the aim was to build and emerge with the meanings constructed by the participants (including me as a researcher) in their situations.

The qualitative method research analysis explored the influence of chess play on learners' mathematics performance. The observation sheets, interviews and video recordings formed the qualitative data. The data collected during this qualitative study were organised and categorised for easy access during data analysis. Qualitative data that was obtained was analysed using thematic analysis. The researcher read through all the raw data (transcripts) to make sense of the entire data. Then, raw data from interviews, observation sheets and video recordings were presented and analysed.

The researcher used triangulation, which involves multiple methods for data collection. Interviews, observation, and video recordings were used to collect data in this study (Polit & Beck, 2012). Triangulation is frequently used as a methodology of enquiry, which involves collecting qualitative data and incorporating them in response to research questions (Creswell, 2014). These two forms of data were integrated into the design analysis by merging the data collected, connecting the data and embedding the data in this study (Creswell, 2014).

Multiple methods provide a combination of data that provides a more robust understanding of the problem or research question than by itself (Creswell, 2014).

## 3.7 ETHICAL ISSUES

A researcher needs to highlight the ethical considerations when conducting research (Maree, 2016). Ethics in research is defined as a matter of principled sensitivity to the rights of others, and while truth is good, respect for human dignity is better (Cavan, 1977 in Cohen, McCabe, Michelli & Pickeral, 2009). The crucial role of the researcher was to inform the participants about the research project's aim, its duration and the key roles each had to play in the research process (Øye, Sørensen & Glasdam, 2016). In an attempt to find the solution to the problem of this study, which aimed to explore the impact of chess games on the understanding concepts of Senior Phase learners in mathematics, the measures to ensure ethical conduct were met as follows.

### 3.7.1 Permissions

#### *3.7.1.1 UFS Ethical clearance*

Permission to conduct the study was applied from the University of Free State Ethics Committee. The researcher obtained ethical clearance from the Faculty of Education Research Committee of UFS to carry out this investigation, The ethical clearance letter is attached as Appendix A in this study.

#### *3.7.1.2 Permission to conduct the study by FSDoE*

Permission to conduct the study in the school was obtained from the Provincial Department of Education, Motheo District Director. Permission is attached as appendix B in this study. Letters requesting permission were sent to the necessary stakeholders.

#### *3.7.1.3 Permission to conduct the study by the principal and the teacher*

A telephonic appointment was made with School principal and mathematics teacher in the Motheo district in the Free State Province. The purpose of the appointment was to request permission to conduct the study and explain how the study will be conducted. Therefore, permission for this study was required from the principal of a primary school in a district and a teacher of Grade 7 mathematics learners. The researcher asked to conduct the interviews in the afternoons and on Saturdays so that it would not affect the smooth running of the school. The ethical measures indicated in the letter to request permission to conduct the study were explained to them upon their approval. The letter requesting permission to conduct the study, including ethical considerations, is attached as Appendices C-I. The following matters were indicated in the letter, namely, the ethics code from UFS, the importance of the study, how the school benefited from the study, how confidentiality was guaranteed, how identity was protected, voluntary participation, permission to capture videos and finally how the audio-visuals were protected. Permission to conduct the study was granted by the school Principal and her mathematics teacher since this study involves the Senior Phase learners of their school. Permission to conduct the research from the principal is attached as annexures H and I while annexure Fand G are consent forms given by the teacher.

### 3.7.2 Informed consent

Consent forms (Appendices C-I) were given to all research participants (teachers, parents, learners and principals) before the research commenced. Participants were informed that they were welcome to withdraw from the research at any stage.

#### *3.7.2.1 Informed consent from learners*

Prior informed consent was obtained from all the learners who participated in this study, who were told they would remain unidentified (Ary et al., 2010). The learners were made aware that through their permission the consent forms were to be signed before the data collection process of this study. The learners were also informed that participating in this study is essential and voluntary. Learners were, therefore, welcome to withdraw at any time should they feel uncomfortable during this study

(Ary et al., 2010). The identity of the learners remained anonymous. Hence, alphabetical letters were used as pseudonyms for confidentiality and anonymity (Ary et al., 2010). Learners were informed that the consequential data from their feedback would be used for reporting and analysis (Ary et al., 2010). Permission to videotape and record learners was granted before the interview by the learners themselves to allow the researcher to listen to the recordings, review the notes and reflect on the process to find any gaps that might require follow-up interviews (Maree, 2016).Permission to conduct the research from the learners is attached as annexures C in this study.

#### *3.7.2.2 Informed consent from parents*

Consent forms were sent to the parents of the learners to get permission from parents to observe learners playing chess as participants in this study as they were minors. This permission ensured learners cooperated in this study and provided data (Creswell, 2014). Furthermore, their approval acknowledged that they understood this study's purpose and were treated ethically (Creswell, 2014). Parents gave consent and the permission to conduct this study is attached as annexure D and E.

## 3.8 PLAGIARISM

All the sources of information used in this study were acknowledged to ensure that the ethical code of plagiarism is adhered to as required. The study proposal and dissertation were submitted to Turnitin for approval.

## 3.9 CREDIBILITY

According to Liao and Hitchcock (2018), credibility is consequently significant while applying approaches, such as deliberation; for instance, recording observations in multiple ways, e.g., using photography, as well as individuals' visual observations and using more than one observer, are ways to increase trustworthiness. The trustworthiness of the data intensifies the natural setting with its flexible, unstructured methodology. At the same time, naturalistic observation regularly captures behaviour that may be unanticipated while focusing on the topic under investigation.

Naturalistic observation gives chances to discover complex phenomena, for instance, collaborations amongst persons in daily life situations, such as managing chess games and developing critical thinking.

Nevertheless, to reach this study's purpose, participants were purposively selected. The interviews, observations and video recordings were triangulated to ensure this research's findings were consistent, reliable and credible. This approach assisted in identifying limitations and biases in this study. The researcher was transparent to the school principal, chess coach as well as the parents on how the research will be conducted the participants were also made aware that the data or information gathered will be used only for the purpose of this study. The participants were free to ask questions regarding the study at any time and the researcher was responding to the questions. The researcher was also on time and do exactly what she said she will do in her request to conduct this research. This was done in order to ensure the trustworthiness of this study.

## 3.10 CHAPTER SUMMARY

This chapter focused on research design and methodology in qualitative research. Population and sampling, instruments for data collection, data collection procedures and data analysis were also discussed. Then, the discussion on how the ethical measures were met in this project was also dealt with. Finally, the fundamental concepts of this research came next: trustworthiness, plagiarism reliability, validity and credibility. The next chapter highlights research results, data analysis and interpretation of the data collected.

# CHAPTER 4
# PRESENTATION, ANALYSIS, AND INTERPRETATION OF DATA

## 4.1 INTRODUCTION

The findings in this chapter were based on data collected from one school (School A) in the Motheo district. The approach in this section is as follows:

The background information of the school is discussed (including the interactions with each of the learners and a brief description of their backgrounds in playing chess), including:

1. The report on the responses that learners offered during the interviews where their responses speak specifically to the research questions; the first part looked into the explanations learners gave on what they love most about chess.
2. The facilitators observed learners as they started playing.

The participants' answers to the last research question that sought their application of engagement knowledge to engage most learners in their in-chess games are also discussed.

## 4.2 BACKGROUND INFORMATION OF THE SCHOOL

One school from the Mangaung township in Motheo was used in this study. Codes were used for the learners from the focus groups. This school is about 5 km from my school. This school was selected because it is known to offer chess, and the school shares the same community with the same economic background as the researcher.

## 4.3 POSITIONALITY OF THE RESEARCHER/ FACILITATOR

The facilitator started her teaching career at this school and has a proven track record of good performance or achievement. She obtained her honours degree in Education at the UJ and has previously taught mathematics to Grade 7 and served on the SGB before becoming the principal at one of the primary schools in the Mangaung township.

## 4.4 BACKGROUND INFORMATION OF CHESS COACHES

The school appointed two chess coaches to monitor and advise a school chess team. One of the chess coaches was initially appointed by the Extended Public Works Programme (EPWP) as a Department of Education initiative to introduce chess games at Senior Primary Phase schools. The second chess coach was appointed as an assistant interested in teaching chess. So, they partnered together to teach chess. Since teaching chess at this school, they have won the district and provincial competitions. The role of the chess coaches is to coach learners in chess, helping them learn the rules and pieces of chess, improve their chess strategies and prepare learners for competitions from the school level to the national level. These chess coaches have been developing an interest in chess among learners at the school level for the past three years.

## 4.5 PROCEDURE

### 4.5.1 Report on the learners' observations

Participants were allowed to play chess in the researcher's presence. Chess coaches were in control, and the researcher did not influence any of the six groups as they started playing. The participants were 29 in total. They were divided into seven (7) groups of four (4) members each, except the last group, which had five (5) members. Participants were grouped according to grade and performance in mathematics. Participants who performed below 30% in both grades were grouped, while the other group consisted of learners whose performance was between 31% and 69%. The last group consisted of learners who had 70% and above. Test mark schedules were used as a reference to indicate the performance of these learners. Chess coaches gave instructions before participants started playing.

The role of the researcher was to observe how they played and take video recordings as they continued playing. Chess coaches did not help or influence any of the groups when busy playing. Learners were observed as they played chess games, and the researcher observed how chess coaches distributed chess boards and pieces to the participants. Learners were noisy before starting the games; however, chess coaches calmed them down and gave them a few rules before they started playing the chess game. Learners concentrated on how to beat the

opponent. One of the rules was that they must warn the opponent by saying “check”. Most interestingly, chess coaches indicated that once a player wins, they must raise their hand.

The winning learners were grouped because they were expected to compete against one another to get an overall winner from each group. Each tried to figure out the solutions, and a young girl finished first and raised her hand. At the end of the game, participants join their original groups. After that, participants were engaged in the interview session that followed.

## 4.6 INTERVIEW QUESTIONS

Below are the participants’ responses to the interview questions.

To protect the identities of the participants, they are referred to as Participant 1 (P1), Participant 2 (P2), Participant 3 (P3), Participant 4 (P4), and Participant 5 (P5).

### 4.6.1 Question 1: What do you like the most about chess games?

*“I like chess because it helps me to think when solving mathematics problems”* (P1).

*“I like chess games because it makes me a free person to follow mathematics steps when solving them”* (P2).

*“I like chess games because it helps me to apply skills learned to solve mathematics problems”* (P3).

*“Chess games improve my performance in mathematics. I was struggling with mental maths, and after joining the chess team at my school, I became cleverer to tackle mathematics problems”* (P4).

*“I now pass the mathematics tests with levels 6 and 7 which is a huge improvement in mathematics performance”* (P5).

*“Chess games make me think fast, and this contributes to solving mathematics easily and fast too”* (P6).

### 4.6.2 Question 2: What do you like least about the chess lessons?

*"There is nothing that I like least about chess lessons. The only thing I like least in chess lessons is losing either a piece or a game. Another thing I like least in chess is when the whole team is losing"* (P1).

### 4.6.3 Question 3: What is your opinion of the influence of chess games on your performance in mathematics?

*"Chess games have improved my thinking level as I now have strategies to solve mathematics problems very fast"* (P1).

*"Chess games have influenced me to think fast when doing tasks in mathematics.' I no longer get low marks in mathematics since playing chess"* (P2).

*"My opinion on the influence of chess in mathematics performance is that since joining chess from January this year, I have started seeing improvement in performance in mathematics"* (P3).

*"Chess games taught me to think before answering any mathematics problem"* (P4).

*"Chess is also the mind game and is similar to solving mathematics problems. My performance in mathematics has improved since playing chess"* (P5).

*"I used to perform at level 4 (four) in mathematics tests in the past, but after joining the chess team and playing it more regularly, my performance has now improved to level 6"* (P6).

### 4.6.4 Question 4: Which specific chess activities have you found useful when solving mathematics problems?

*"When I move chess cones on the chess board, I think that this is similar to multiplication in mathematics. When an opponent says 'check', I now know that is mathematics"* (P1).

*"Chess activities are like using graph numbers. Other participants did not answer this question sufficiently enough"* (P2).

### 4.6.5 Question 5: Chess involves a deep level of thinking and prediction related to what opponents will do before you make your own move to pre-empt the moves by your opponent. How does this relate to how you solve mathematics problems?

*"You must be sure when you move your cones or answer questions in mathematics"* (P1).

*"Numbers must be in the correct place in mathematics just like moving pieces in chess games"* (P2).

*"I think you must think before you write or solve mathematics problems just like you touch or move the pony"* (P3).

### 4.6.6 Question 6: When you compare a chess game and top-solving mathematics problems, what do you find similar in the process?

*"Both chess games and mathematics make you think hard to get a solution"* (P1).

*"Chess is not similar to mathematics numbers but makes you think like in solving mathematics problems"* (P2).

### 4.6.7 Question 7: Do you find differences in the process when comparing a chess game with top-solving problem mathematics?

*"No, I find out that the only difference in the process is the use of letters and numbers. In chess, we use only the ponies"* (P1).'

*"There is just a bit of difference. Sometimes chess is easier than mathematics, hence the difference"* (P2).

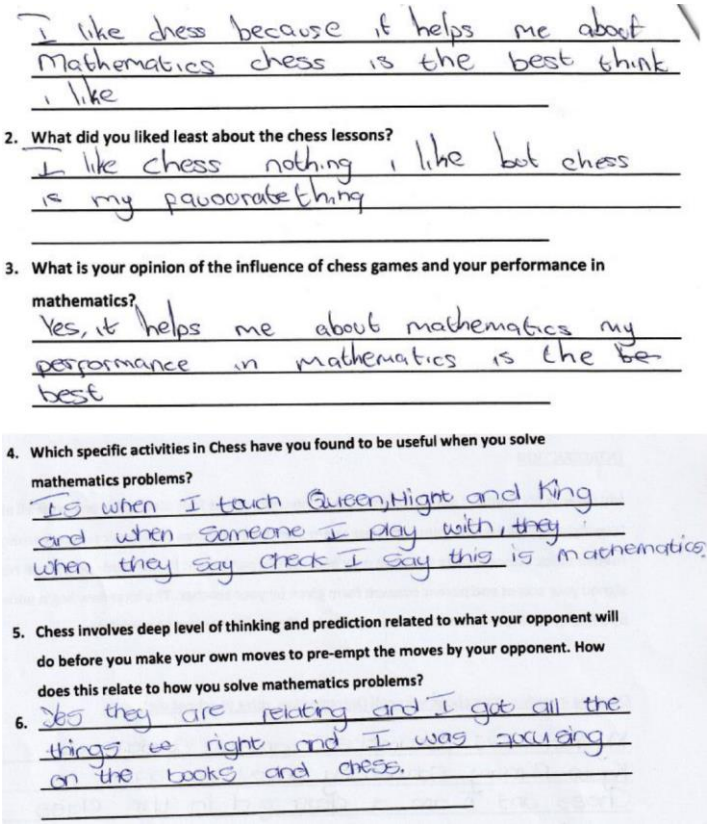
*"In chess, you think longer and in mathematics, you need to think fast to use problem-solving skills because of the limited time given to answer a number of questions"* (P3).

*"There is no difference because chess games and mathematics are the same"* (P4).

*"I think there is no difference because, in both chess games and mathematics, you have to think hard"* (P5).

Learners 4, 6, 8, 9, 10, 11 and 12 did not answer this question.

Figure 4.1 below indicates the sample of interviews schedules completed by the learners. These questions were also communicated verbally to the participants.



I like chess because it helps me about Mathematics chess is the best think I like

2. What did you liked least about the chess lessons?

I like chess nothing I like but chess is my favourate thing

3. What is your opinion of the influence of chess games and your performance in mathematics?

Yes, it helps me about mathematics my performance in mathematics is the be- best

4. Which specific activities in Chess have you found to be useful when you solve mathematics problems?

Is when I teach Queen, Night and King and when someone I play with, they when they say check I say this is mathematics

5. Chess involves deep level of thinking and prediction related to what your opponent will do before you make your own moves to pre-empt the moves by your opponent. How does this relate to how you solve mathematics problems?

6. Yes they are relating and I got all the things be right and I was focusing on the books and chess.

3. **What is your opinion of the influence of chess games and your performance in mathematics?**

Yes because last year on my maths I used to get level 4 and this year I am with level 6

4. **Which specific activities in Chess have you found to be useful when you solve mathematics problems?**

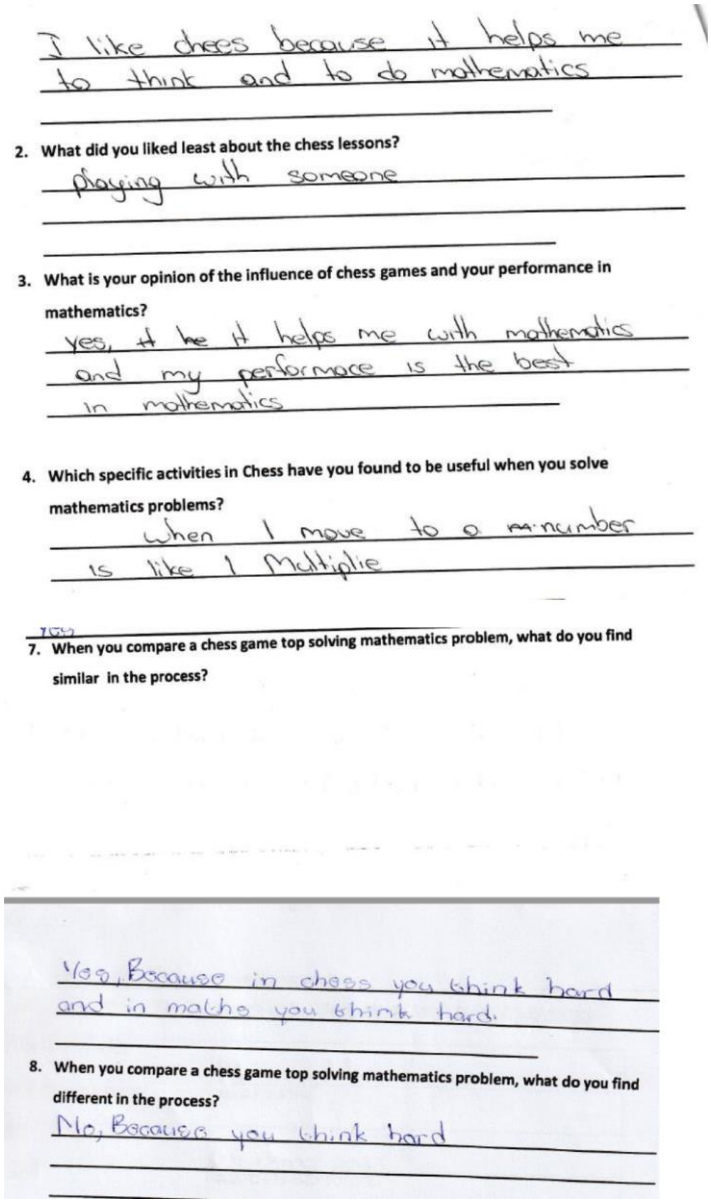
Four move check mate

4. **Which specific activities in Chess have you found to be useful when you solve mathematics problems?**

At F5, F8 and I like to mathematics and chess

5. **Chess involves deep level of thinking and prediction related to what your opponent will do before you make your own moves to pre-empt the moves by your opponent. How does this relate to how you solve mathematics problems?**

6. yes, Because they are relating



I like chess because it helps me to think and to do mathematics

2. What did you liked least about the chess lessons?

playing with someone

3. What is your opinion of the influence of chess games and your performance in mathematics?

yes, it he it helps me with mathematics and my performace is the best in mathematics

4. Which specific activities in Chess have you found to be useful when you solve mathematics problems?

When I move to a number is like I Multiplie

7. When you compare a chess game top solving mathematics problem, what do you find similar in the process?

Yes, Because in chess you think hard and in maths you think hard.

8. When you compare a chess game top solving mathematics problem, what do you find different in the process?

No, Because you think hard

***Figure 4.1: Interview schedules completed by the learners***

## 4.7 EMERGING THEMES DURING THE INTERVIEWS

### 4.7.1 Strategic learning

Learners indicated that through chess games, they have developed strategies to understand mathematical concepts and learn how to respond to them easily. This theme is supported by the response of learners who indicated that they have improve their understanding of mathematical concepts. Learners responded that chess games helped them understand quicker when solving mathematics problems.

Some learners said playing chess developed problem-solving skills they apply to solving mathematics problems.

### 4.7.2 Problem-solving skill

Learners responded that when they play chess, they apply skills learned to develop problem-solving skills relevant to solving mathematics problems.

### 4.7.3 Use of letters and numbers

Learners responded that in mathematics, they use letters, symbols and numbers to solve mathematical issues. In contrast, chess games only use the chess pieces' movements that are unrelated to any numbers.

### 4.7.4 Quietness

Learners responded that when they play chess, there is no talking to each other unless the play warns the opponent to ‘check’. There is always complete quietness as they observe the movement of chess pieces by the opponent to grab the opportunity to win most of the opponents’ pieces when they have left them unprotected.

### 4.7.5 Concentration/attentiveness

Learners responded that you must concentrate on winning the chess game, which is critical to observing how your opponent moves chess pieces. Concentration makes you see gaps your opponent opens and not be aware of. The themes relate to maths problem-solving as learners relate this to chess games.

### 4.7.6 Observation as data collection tool

#### *4.7.6.1 Interest (learners showing positive emotions)*

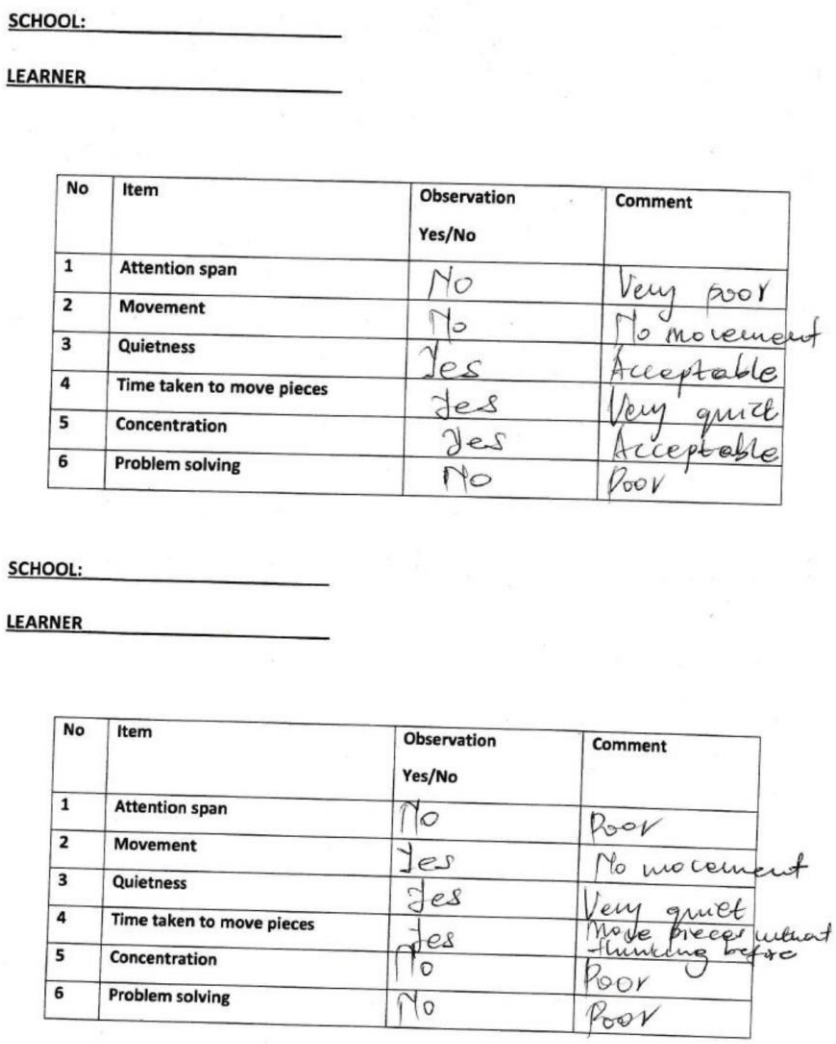
Learners indicated that they are interested in playing chess games as it makes one think fast when checking on the movement of chess pieces by your opponent. This

theme is connected to learners' emotions. Chess games make learners love it – winning or losing is fun. Engaged learning of chess games also engages with quietness.

#### *4.7.6.2 Observations*

Twenty-nine (29) learners were observed while playing chess. The main focus of the observation was on assertiveness, discipline, concentration, patience, emotional intelligence and problem-solving. The observation sheet is attached as Appendix K. The class was observed on Wednesday afternoon, and the learners were at their study tables. Chess coach began by introducing the researcher and explained the purpose of the game of chess. The chess coaches started with a whole class discussion; it was followed by grouping all winners of the first round to compete among themselves; finally came the presentation of how they best enjoyed the first game. Learners were observed when they started playing chess. This challenge warmed up the class as learners tried to figure out how they would begin to play chess games. Then the chess coaches distributed chess boards and chess pieces to all learners. Learners were then allowed chess activity and challenged each other to do their best in these games, outlining how the lesson unfolded. When moving around and observing playing pares, the facilitator asked one of the players why she moved her chess pieces that way. She replied by saying her opponent did observe her strategic movement for her to win more chess pieces from her. She effectively explained her strategies. During the chess game, learners concentrated on how they moved chess pieces. If one player became aware that the opponent is about to lose, he or she indicated by the word 'check'. There was no noise at all when they were playing. It is worth noting that it was necessary for the learner to demonstrate to the facilitator how easy it is to win a chess game. These games have influence on solving mathematics problems in that mathematics needs one to concentrate and think quickly. So, playing chess is closely related to solving mathematics problems. The same attitude displayed when playing chess is replicated when solving mathematics problems. Attention was measured by the time taken to move a chess piece.

The figure below indicated one of the learner's observation sheets during chess play.



SCHOOL: _____

LEARNER _____

| No | Item | Observation Yes/No | Comment |
|---|---|---|---|
| 1 | Attention span | No | Very poor |
| 2 | Movement | No | No movement |
| 3 | Quietness | Yes | Acceptable |
| 4 | Time taken to move pieces | Yes | Very quiet |
| 5 | Concentration | Yes | Acceptable |
| 6 | Problem solving | No | Poor |

SCHOOL: _____

LEARNER _____

| No | Item | Observation Yes/No | Comment |
|---|---|---|---|
| 1 | Attention span | No | Poor |
| 2 | Movement | Yes | No movement |
| 3 | Quietness | Yes | Very quiet |
| 4 | Time taken to move pieces | Yes | Move pieces without thinking before |
| 5 | Concentration | No | Poor |
| 6 | Problem solving | No | Poor |

***Figure 4.2: Learners observation sheets***

## 4.8 SUMMARY OF THE CHAPTER

The chapter has presented the study's findings in line with the study's objectives. Learners were observed when playing chess and, after that, were exposed to interview questions. These learners were not novice chess games. Some learners indicated how chess games had improved their performance in mathematics. Test mark sheets were used as references in this study, revealing that there has been an improvement in performance in mathematics since they started playing chess.

> *"Mathematicians who play chess usually admit that chess is a part of mathematics, and it is the most mathematical of all strategic games. Mathematics is considered the queen of the sciences, while Chess is the queen of all board games. Both share an*

*abstract way of reasoning in solving problems. Mathematics, like chess, is one of the things where constant practice, constant thinking, imagining, and studying are necessary to achieve mastery of the subject"* (Bill, 2015).

Therefore, a good chess player can be a good mathematician if adequately trained and educated.

## 4.9 CONCLUSION

The findings from the study shed some light on how chess games influenced the performance of learners in mathematics in one of the township primary schools in the Motheo district where learners were engaged. Each learner was treated as not a novice chess player, and the data came from interview observation sheets. Emerging themes from the collected data were highlighted and discussed. The chapter also looked at data collected from each research question. The interpretation of these results is presented in the next chapter.

# CHAPTER 5
# DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

## 5.1 INTRODUCTION

The focus of this chapter is on the discussion of the results of this study, considering the limitations of this research and recommendations. It featured the perspectives, as well as the experiences, of Senior Phase learners who are already playing chess, which is to explore how chess games influence their understanding of mathematics in the Motheo district in the Free State Department of Education.

The general overall objective of this study was to solicit explanations of how chess influences learners' understanding of mathematics in the Senior Phase and to establish how chess knowledge is helping them with problem-solving skills in mathematics. To achieve this objective, the researcher conducted an extensive literature review about how chess games improved learner understanding in mathematics. This chapter concludes this study with interpretations of the results guided by the research questions and the theoretical framework from the literature. Then, the limitations of this research are discussed. Lastly, recommendations for future research on similar educational topics and overall conclusions. As a result, research questions were formulated and responded to by learners whose parents signed consent forms to allow them to participate in this study.

The finding of the recent study demonstrates that chess games positively influence the understanding of learners in mathematical concepts. Bill (2015) asserts that famous chess players who are also mathematicians, namely Adolf Anderson (1818-1879), Emanuel Lasker (1868-1941), Albert Einstein (1879-1955), Max Euwe (1901-1981), Paul Keres (1916-1975); and Karsten Mueller (1970) had initially started playing chess. Hence, they became mathematicians, as stated above.

## 5.2 DISCUSSION OF RESEARCH RESULTS

This study aimed to explore the effects of chess games on the understanding of learners in mathematics.

### 5.2.1 Main research question

The main research question for this study that was addressed during the focus group interviews was:

***What is the impact of the game of chess on the mathematical understanding of Senior Phase learners in mathematics?***

The main research question aimed to establish chess's impact on Senior Phase learners' performance. This research question is aligned with the nature of the study and how this study was undertaken.The researcher used her knowledge of the benefits of chess from the literature and information from the data to draw conclusions about the findings relating to these research questions. Participants responded by saying that since they started playing chess, they have experienced improvement in their understanding in mathematics. These findings are corroborated by Bill (2014), who indicated that chess game intervention during mathematics teaching has a positive cognitive effect on regular school learners. Barret and Fish (2011) have supported the view that chess intervention during mathematics teaching has a positive cognitive effect on typical school learners.

It is obvious that learners were most impressed during the interview, and they mentioned it as a sign that their understanding in mathematics has improved since their engagement in these games. Learners also noted that they have improved on their strategies in solving mathematics problems. They have also learned the following elements:

1. Completing mathematics problems by thinking fast.
2. Attentiveness during chess games and mathematics lessons.
3. Interacting with other learners
4. Showing positive emotions (interest)
5. Connecting the chess game rules.
6. Commitment and participation in learning chess games and mathematics.

These themes emerged as they were raised by learners who demonstrated how chess games influenced their behaviour when playing these games and their attitude in tackling mathematics problems. These themes also indicated how the affective elements illustrate learners' interactions with their peers and chess coaches. That means chess games influenced learners’ performance in mathematics.

### 5.2.2 Research sub-questions

The following are research sub-questions.

#### *5.2.2.1* ***Research sub-question 1: What is the relationship between the use of chess and learners' understanding of mathematics?***

The second sub-question enquired about the relationship between chess use and learners' mathematics understanding. The crux of the matter was that learners indicated to the facilitator that they perceived that chess games are most effective as they now perform better in mathematics (above levels 5 and 6) since engaging in chess lessons. Participants showed in their responses that there is this connection between chess and mathematics because chess and mathematics make you think. In mathematics, you need to think fast to solve problems. Participants further indicated that in chess, you move chess pieces. Participants said this is similar to multiplication in mathematics: "When an opponent says 'check', I now know that is mathematics". Chess playing during mathematics lessons may also positively affect domains such as problem-solving, concentration, and self-discipline (Sigirtmac, 2011). The process of teaching problem-solving includes the strategies that the learners apply in solving problems and the learner's method of thinking in solving non-algorithmic problems (McIntosh, 2011). The above concurs that there is a strong connection between chess games and mathematics.

Furthermore, Peterson (2002 in Berkley, 2012) asserts that implementing chess into the mathematics curriculum is crucial for the mental development of learners. Peterson applied chess to his mathematics classroom because he felt it would improve learners' problem-solving skills. According to Berkman (2004) and Celone (1999, cited in Berkley, 2012), studying a chess point has much in common with solving a problem in mathematics. The data from the learners' interview forms

revealed a high affective engagement among learners in chess games. Hunt and Cangemi (2014) assert that chess games positively affect mental development and engage learners in solving high-skill mathematics problems.

During the interview, learners indicated that they had developed new strategies for solving mathematics problems. Learner's problem-solving skills may be established on the condition that no personal or external factors obstruct the learning process. Green and Gillhooly (2005, cited in Giannakopoulos, 2012) and Schoenfeld (1979, cited in Halpern, 1997) corroborated that chess play during mathematics lessons may also have positive effects in domains such as problem-solving, concentration and self-discipline (Sigirtmac, 2011), which is in line with findings during the interviews in this study. Green and Gillhooly (2005, cited in Giannakopoulos, 2012) further assert that there are three types of problem-solving: simple, analogical and complex problem-solving phase mathematics learners. Hence, learners, in their response to the interview, indicated they can solve complex mathematics problems. In explaining how she perceives the relationship between chess games and mathematics skills, the researcher mentioned that learners indicated that they left mathematics problems unsolved in the past. Still, ever since they engaged in chess games, they have improved a lot in that regard.

Trinchero and Sala (2016) assert that chess training corresponds with mathematical problem-solving ability because children must be able to identify and understand a situation, study different ways to solve the problem, choose the best decision and monitor its consequences when encountering mathematical problems. The data from the learners' observation sheets and mark schedules or forms also aligned with the findings from the observation sheet, as average scores were high on affective and constructivist engagement in tackling mathematics problems. According to Ercikan, McCreith, and Lapointe (2005, cited in Giannakopoulos, 2012), individual and family environments have an influence on learner achievement and are not dependent on culture and the educational system. This finding reveals the possibility that learner's knowledge of chess game engagement could be low, yet chess coaches could be able to engage most of the learners in the classroom. One of the justifications the researcher provided for using three instruments for data collection was that using semi-structured interviews could only result in conclusions based solely on the chess educator's ability to articulate, which could limit the scope of the research, making a strong affirmation for triangulation.

#### 5.2.2.2 *Research sub-question 2: How can the game of chess be used to improve the understanding of senior phase learners in mathematics?*

Three groups of learners who were acquainted with chess participated in this study. First, there was a significant improvement in the performance of chess-playing learners in this school. Second, there was a substantial contribution between chess lessons and problem-solving in mathematics. This study revealed that chess lessons provide support that facilitates the transfer of cognitive skills to deal more with mathematics problem-solving experienced by learners in Grades 6 and 7, respectively. In chess, one must engage in this sequence of (1) position comprehension, (2) pattern induction, and (3) move formulation and evaluation relatively quickly. This coordinated set of cognitive skills required in competent chess play likely transfers to learning mathematics and related fields that also often require comprehension, induction, analysis, and evaluation of complex phenomena (Barret & Fish, 2011). Hunt and Cangemi (2014) assert that chess games positively affect mental development.

All interviewed participants revealed that they had experienced tremendous improvement in mathematics problem-solving since playing chess. Notably, positive emotions were expressed by mentioning the influence of chess lessons that improved learners' understanding in mathematics at school. Furthermore, Barret and Fish (2011) have supported the view that chess intervention during mathematics teaching has a positive cognitive effect on regular school learners.

Some learners expressed how chess lessons empowered them to be strategic when answering mathematics problems. As for perceived competence, the findings show that almost all learners in this study have improved a lot in mathematics problem-solving since they engaged in chess games. Some indicated that they were previously performing at level 4, but since playing chess, they have improved up to level 6. Previous studies have found that gifted students perform well in mathematics and that their belief in their ability to perform Mathematical tasks is higher than that of other students (Adediwura, 2011). Although the results of this study support previous studies about the influence of chess games in improving performance in mathematics, they show that all learners might not find themselves competent in mathematics; chess has received less consideration than it deserves as an

educational instrument that can benefit the teachers and policymakers to advance academic performance of learners (Williams, 2014).

This coordinated set of cognitive skills required in competent chess play likely transfers to learning mathematics and related fields that also often require comprehension, induction, analysis, and evaluation of complex phenomena.

Most learners (17) from Grades 7 take their performance improvement on mathematical tasks as a criterion of competence and, according to their views during focus group interviews, attribute it to chess lessons. When chess lessons were considered together, the study's findings revealed that all 17 learners have a positive attitude towards mathematics as their performance has tremendously improved. The study showed that learners prefer some chess lessons where they do not want to lose them; for instance, one of the participants expressed the view that ‘they do not want to lose any of the chess games. In chess games, one engages in this sequence of (1) position comprehension, (2) pattern induction, and (3) move formulation and evaluation relatively quickly (see the observation sheets in Chapter 4). This coordinated set of cognitive skills required in competent chess play likely transfers to learning mathematics and related fields that also often require comprehension, induction, analysis, and evaluation of complex phenomena. The participants' experiences specify how chess became valuable and significantly contributed to their performance in mathematics and lives in general.

With game-based, discovery-oriented and challenging tasks, learners’ visions of mathematics and perceived competence can be reinforced. Tasks such as writing problems and solutions, solving simple questions, and revising the lessons support their ways of learning and making sense of mathematics problem-solving skills. Furthermore, playing chess helped learners like and apply mathematics in chess, which enhanced their cognitive skills and school performance (Joseph et al., 2016; Trinchero & Sala, 2016). The result of this study can be used as a baseline in reviving the implementation of the incorporation of chess in the Department of Education curriculum. Curriculum planners could design a framework (Pawilen & Manuel, 2018) for chess instruction in each school in the country. Each educational leader should support the cry for integrating chess instruction in schools, beginning from the preschool level.

Moreover, mathematics teachers who are also chess players should utilize chess puzzles to deepen learners' understanding of the subject and propose an easy and efficient way of solving problems (Salangsang & Subia, 2020) to reduce learners' difficulties in mathematics at schools.

Lastly, educators may explore and adopt other game-based instruction in their classroom and discover those that can help increase the engagement and achievement of their students and cater to their individual learning styles.

One limitation of this research is the number of participants interviewed. To fully validate the result and for the study to be generalizable, an additional number of samples using a quantitative research design is recommended. Another limitation of this study is the proper measurement of the participants' improvement in mathematics and the enhancement of their cognitive skills because of playing chess. Thus, it is recommended that an experimental study determining the learners' critical thinking skills and mathematical abilities be conducted to verify that such an underlying correlation is real. Furthermore, chess games should be used to enhance the teaching of mathematical concepts such as number patterns. Chess games have patterns which learners can also apply in understanding number patterns in mathematics as stipulated in CAPS document.

Sadik (2006, in Sigirtmac, 2012) also found that the performance of basic operations of fourth and fifth-grade mathematics learners who knew how to play chess was higher than their counterparts who had never played chess before. According to Trinchero (2013), chess is one of the most common games associated with concepts such as intelligence, strategy and reasoning. Many researchers, such as Kazemi et al. (2012), Sala et al. (2015) and also Trinchero (2012, in Trinchero & Sala, 2016), have claimed that chess training increases children's Mathematical skills because playing chess helps to form the thinking of the learners mostly when facing the mathematical problems. Chess lessons are inevitable to the development of creativity and critical thinking in the learning of mathematics. The benefits of chess in learner achievement are also evident in blended learning, as indicated by Trinchero (2013). According to Trinchero (2013), intervention of blended chess training can improve learner achievement on the OECD-Pisa Mathematics scale. To this end, this study tried to provide evidence of the influence of chess games towards the improvement of performance in mathematics by primary school learners.

#### *5.2.2.3* ***Research sub-question 3: How do chess games affect learners understanding of concepts in mathematics?***

The third sub-question investigated how chess games affect learners understanding of concepts in mathematics. According to CAPS mathematics grade 7 the concept which was addressed by the learners was numeric and geometric patterns. During the data collection process of this study the grade 7 learners were in week 8 of Annual Teaching Plan (ATP) which addresses representation of number patterns in physical or diagram form. Therefore, participants responded by indicating that movement of chess pieces during chess games does show patters which contributed to their understanding of number patterns in mathematics. Participants showed in their responses that there is this connection between chess games and number patterns because chess games make you think better in mathematics. The findings is corroborated by many studies which have examined the positive effects of chess on children's mathematical understanding (Sala, Gorini & Pravettoni, 2015; Kazemi, Yektayar & Abad, 2012; Trinchero, 2013; Barrett & Fish, 2011). Barrett and Fish (2011) examined the effectiveness of chess training on children's mathematical development in special care centres using the Texas Assessment of Knowledge and Skills (TAKS) program, whose results showed that the chess training group performed better in mathematics than the control group.

## 5.3 LIMITATIONS OF THE STUDY

Although this study has shown improved performance, it should not be conceived that there were no limitations. Limitations for this present study were:

i.) Only one school was used for this study.
ii.) The study could have been carried out between districts and provinces.
iii.) The time spent for observation and interviews with participants could still be increased for better outcomes.
iv.) There were disruptions and delays when the venue was ready and still being cleaned before we could begin the study.
v.) Interviews were held only with learners, not chess coaches. Research findings and reports on learners' performance in mathematics continue to highlight poor performance in this subject.

This study was carried out in the Free State Province district, Motheo. Attention was paid to Motheo, as the researcher is employed in this district as the principal of one of the primary schools. It was suitable for the researcher to conduct this study where data could be gathered, specifically in the school where learners play chess. It would be more useful if similar research were done in all districts entirely and would generate attentiveness to the worth of chess games in the influence of these games on the performance of learners in mathematics. It would also be significant for academic literature to contribute to the influence of chess on the performance of learners in mathematics.

## 5.4 RECOMMENDATIONS

Some work has been done on the influence of chess lessons on improving mathematics performance, specifically for primary school learners. Individual organisations, professional bodies, stakeholders, and the government have endeavoured to improve mathematics performance.

In light of the above, efforts have inevitably been made to improve the performance of mathematics in this province.

Given all that has been mentioned above, this study recommends that:

1. All primary schools should always strive to use chess lessons as extra-curricular activities.
2. It is essential to have introductory courses for all interested educators to assist learners with chess games at school.
3. Consequently, according to the findings of this study, chess significantly contributes to improving learners understanding in mathematics concepts. The establishment of chess programmes in primary schools has worked perfectly in some countries where the responsibility for teaching chess lies with grandmasters and chess instructors.
4. Since chess games have shown improvement in the understanding of learners in mathematics, it is recommended that primary schools be encouraged to have these as extracurricular games.

5. Chess should be used in schools to help learners to understand mathematical concepts when teaching topics such as patterns as indicated in CAPS document.

Williams (2014) concurs with Sigirtmac (2012) by demonstrating that chess play positively influences the learners' academic achievement in mathematics. This assertion was further confirmed during the observation when learners were playing chess.

## 5.5 CONCLUSION

Since there is not enough research in the field where chess games seem to influence the undertanding of primary school learners in mathematics, the researcher would like to recommend that efforts be made to encourage more research into this area – this is another virgin area in education. Each game grants itself with new problems to solve during a chess game. Playing chess has been closely connected with critical thinking. Playing chess improves the individual’s critical thinking skills (Berkley, 2012).

Another future research could be the addition of chess lessons as a extra-curricular activity to enhance chess coaches' training skills for learners. This study's findings suggest that the transfer of skills gained through chess practice to the academic domain is worth further investigation. Future research should be undertaken using the same qualitative design and a longitudinal approach to investigate the effects of chess practice over time.

Unfortunately, until chess is provably incorporated into school extra-curricular activity, a player’s skills cannot be perfected. While this may be true, chess skills can still be significantly improved. The best way to enhance chess skills is to take the time to analyse and understand the game. As demonstrated in the study, mathematics exists inherently in chess games. Hence, participants claimed that they had seen improvement in mathematics due to playing chess games. Attempts must be made to overcome hurdles in search of the influence of chess games in improving performance in mathematics. Each game presents itself with new problems to solve during a chess game.

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## APPENDICES

## APPENDIX A: UFS ETHICAL CLEARANCE

UNIVERSITY OF THE FREE STATE
UNIVERSITEIT VAN DIE VRYSTAAT
YUNIVESITHI YA FREISTATA

UFS UV

**GENERAL/HUMAN RESEARCH ETHICS COMMITTEE (GHREC)**

23-Mar-2023

Dear Mrs Gohelane Mathe

**Application Approved**

Research Project Title:
**Exploring the use of chess games to improve performance of senior phase learners in mathematics.**

Ethical Clearance number:
**UFS-HSD2022/0612/23**

We are pleased to inform you that your application for ethical clearance has been approved. Your ethical clearance is valid for twelve (12) months from the date of issue. We request that any changes that may take place during the course of your study/research project be submitted to the ethics office to ensure ethical transparency. furthermore, you are requested to submit the final report of your study/research project to the ethics office. Should you require more time to complete this research, please apply for an extension. Thank you for submitting your proposal for ethical clearance; we wish you the best of luck and success with your research.

Yours sincerely

**Dr Adri Du Plessis**
**Chairperson: General/Human Research Ethics Committee**

Adri Du Plessis
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## APPENDIX B: PERMISSION TO CONDUCT RESEARCH FROM THE FS DoE

Enquiries: M.Z. Thango
Ref: Research Permission for Extension: G.E. Mathe
Tel. 051 404 8808
Email: MZ.Thango@fseducation.gov.za

education
Department of Education
FREE STATE PROVINCE

40 Bandolier Road
Fleurdal
Bloemfontein
9301

Dear Mrs. G.E. Mathe

**PERMISSION FOR EXTENSION TO CONDUCT RESEARCH IN THE FREE STATE DEPARTMENT OF EDUCATION: MOTHEO DISTRICT**

This letter serves to inform you that you have been granted permission for extension to conduct research in the Free State Department of Education within the Motheo Education District. The details in relation to your research project with the University of the Free State are as follows:

**Topic:** Exploring the use of chess games to improve performance of senior phase learners in Mathematics.

1. **List of schools involved:** Kgato Primary School.
2. **Target Population:** Seventy-five learners doing Mathematics in grade 7 at the selected school.
3. **Period of research:** From the date of signature of this letter until 30 September 2023. Please note that the department does not allow any research to be conducted during the fourth term (quarter) of the academic year. Should you fall behind your schedule by three months to complete your research project in the approved period, you will need to apply for an extension. The researcher is expected to request permission from the school principals to conduct research at schools.
4. The approval is subject to the following conditions:
   4.1 The collection of data should not interfere with the normal tuition time or teaching process.
   4.2 A bound copy of the research document should be submitted to the Free State Department of Education, Room 101, 1st Floor, Thuto House, St. Andrew Street, Bloemfontein or can be emailed to the above-mentioned email address.
   4.3 You will be expected, on completion of your research study to make a presentation to the relevant stakeholders in the Department.
   4.4 The ethics documents must be adhered to in the discourse of your study in our department.
5. Please note that costs relating to all the conditions mentioned above are your own responsibility.

Yours Sincerely.

Mr. MZANDILE W. JACOBS
DIRECTOR: QUALITY ASSURANCE, M&E AND STRATEGIC PLANNING

DATE: 10/03/2023

Enquiries: M.Z. Thango
Ref: Notification of Research Extension: G.E. Mathe
Tel. 051 404 8808
Email: MZ.Thango@fseducation.gov.za

education
Department of Education
FREE STATE PROVINCE

District Director
Motheo District

Dear Mr. Molol

**NOTIFICATION OF RESEARCH EXTENSION: PERMISSION TO CONDUCT RESEARCH PROJECT IN MOTHEO DISTRICT**

This letter serves to inform you that Mrs. G.E. Mathe has been granted permission for extension to conduct research in the Motheo District under the auspices of the University of the Free State. The details in relation to the research project are as follows:

**Topic:** Exploring the use of chess games to improve performance of senior phase learners in Mathematics.

1. **List of schools involved:** Kgato Primary School.
2. **Target Population:** Seventy-five learners doing Mathematics in grade 7 at the selected school.
3. **Period of research:** From the date of signature of this letter until 30 September 2023. Please note the department does not allow any research to be conducted during the fourth term (quarter) of the academic year nor during normal school hours. The researcher is expected to request permission from the school principals to conduct research at schools.
4. **Research benefits:** It is anticipated that the findings of this study may provide opportunity towards assisting senior phase learners to develop their Mathematical performance skills through chess games. The skills used in chess games may be transferred to other learning areas such as Mathematics. The study may also highlight to the South African policymakers the importance of including chess games in the curriculum in order to develop mathematical abilities during Mathematics lessons.
5. Strategic Planning, Policy and Research Directorate will make the necessary arrangements for the researchers to present the findings and recommendations to the relevant officials in the Department.

Yours Sincerely,

Mr. NZAMO W. JACOBS
DIRECTOR: QUALITY ASSURANCE, MSE AND STRATEGIC PLANNING
DATE: 10/03/2023

## APPENDIX C: CONSENT LETTERS (LEARNERS)

University of the Free State Faculty: Education Department: Mathematics Education

Participant's letter of informed assent
Research theme: "To explore the influence of chess games on the performance of senior phase learners in mathematics".

Dear Grade 7 learner
I am currently completing my major dissertation as part of the requirements for my Master's Degree in Mathematics Education. The purpose of this project is to determine whether knowledge and interaction in game of chess may improve learner's performance. I would like to invite you in this project. The following information is provided to help you to decide whether you wish to be part of this project or not.

Your participation in this study is voluntary. You are free to withdraw your consent to participate in this study any time during this study. If you decide to withdraw there will be no consequences to you or your mathematics marks.

The research process will include interviews and observation sheets during mathematics lesson. You will be observed while playing chess and after this then the interviews will be completed with only selected learners for this project. I humbly request to use a tape recorder and a camera in your class in order to have the recorded pictures of this process. After the process of the study the records and pictures of your school and class will be stored safely and will only be viewed by me and be destroyed after completion of this project.

You are welcome to ask questions about the study before participating in this study or during this study. On your request, I intend to share findings of this research with you after the research is completed. I will ensure your confidentiality by keeping your identity hidden through using a pseudonym during data analysis and reporting of this research.

There are no known risks and/or discomforts related with this project. The benefits of this study is to give the school and our district the informed decision with regard games of chess during mathematics class which might improve the mathematics results in the schools. The

recommendations after the findings to this study will not only benefit the school and the district but will also benefit the province and perhaps the whole country in order to make the informed decisions in mathematics teaching to ensure improvement of mathematics achievement of the learners.

Please sign this consent form. You are signing it with full information of the nature and purpose of this study.

Thank you for considering to participate in this study.

…… ……

Gohelane Mathe Prof. Mosimege

M.Ed Student Research supervisor

I agree to participate in the above study and give my permission for the observations and interviews to be video recorded.

…… …….. …….

Learner name Signature Date

## APPENDIX D: CONSENT LETTERS (PARENTS)

University of Free State Faculty: Education Department: Mathematics Education

Parents letter of informed assent
Research theme: “To explore the influence of chess games on the performance of senior phase learners in mathematics.”

Dear Grade seven parent
I am currently completing my major dissertation as part of the requirements for my Master’s Degree in Mathematics Education. This project is concluded under the supervision of Prof Mosimege of the University of Free State. The research will be conducted in grade seven mathematics class. The purpose of this research is to explore the influence of chess games on the performance of senior phase learners in mathematics.

I humbly request your permission for your child to participate in this research however a group of learners in your child’s class are also being invited to participate. The following information is provided to help you to decide whether you wish your child to be part of this project or not.

Your child’s participation in this study is voluntary. You and your child are free to withdraw your consent to participate in this study any time during this study. If you decide to withdraw there will be no consequences to you, your child’s mathematics marks.

The research process will include observations and interviews. Through your permission, your child will be observed while playing chess and after this then the interviews will be completed with only selected learners for this project. I humbly request to use a tape recorder and a camera in your child’s class in order to have the recorded pictures of this process. After the process of the study the records and pictures of your child’s school and class will be stored safely and will only be viewed by me and be destroyed after completion of this project. I intend to share findings of this research with your child’s teacher after the research is completed because it might hopefully assist the teacher in his teaching of Mathematics. I will ensure confidentiality of your child by keeping their identity hidden through using a pseudonym during data analysis and reporting of this research.

There are no known risks and/or discomforts related with this project. The benefits of this study is to give the school and our district the informed decision with regard games of chess during mathematics which might improve the mathematics results in the schools. The recommendations after the findings to this study will not only benefit the school and the district but will also benefit the province and perhaps the whole country in order to make the informed decisions in mathematics teaching to ensure improvement of mathematics achievement of the learners.

Please sign this consent form to give a permission for your child to be participate in this study. Furthermore your child will also sign the consent form to indicate his/her willingness to participate in this study.

Thank you for considering your child to participate in this study. Please return the reply slip to your child's Mathematics teacher by……(date)

Gohelane Mathe Prof. Mosimege
M.Ed Student Research supervisor

## APPENDIX E: CONSENT LETTERS (PARENTS)

University of the Free State Faculty: Education

Grade seven parents letter of informed assent
Research theme: “To explore the influence of chess games on the performance of senior phase learners in mathematics”.

I ……(parent’s full names) parent or legal guardian of ……(name of a child) give/do not give (circle that which is relevant) permission for my child to participate in the above mentioned study and give my permission for the observations and interviews to be video recorded.

…… …….. …….
Parent name Signature Date

…… ……
Gohelane Mathe Prof. Mogege Mosimege
M.Ed Student Research supervisor

## APPENDIX F: CONSENT LETTERS (TEACHER)

University of Free State Faculty: Education Department: Mathematics Education

Teacher's letter of informed assent
Research theme:
"To explore the influence of chess games on the performance of senior phase learners in mathematics"

Dear Teacher

I am currently completing my major dissertation as part of the requirements for my Master's Degree in Mathematics Education. This project is concluded under the supervision of Prof Mosimege of the University of the Free State. With your permission, the research will be conducted in your class with grade seven mathematics learners to determine whether chess games may improve performance of senior phase learners in mathematics. You will be observed while you supervise a group of learners playing chess games during mathematics period. Furthermore, your learners will requested to complete the interview questions. Attached please find the copies of consent letters that your grade seven mathematics parents and learners will receive.

Your participation in this study is voluntary. You are free to withdraw your consent to participate in this study any time during this study. If you decide to withdraw there will be no negative consequences to you or your learners. Participating in this research will not influence your learner's Mathematics marks.

After the process of the study the records and pictures of your class will be stored safely and will only be viewed by me and be destroyed after completion of this project.

On your request, I intend to share findings with you after the research is completed because it might hopefully assist you in teaching of Mathematics. I will ensure everyone's confidentiality by keeping their identity hidden through using a pseudonym during data analysis and reporting of this research.

There are no known risks and/or discomforts related with this project. This study may improve your learner's scores in mathematics. The recommendations after the findings to

this study will not only benefit you, the school and the district but will also benefit the province and perhaps the whole country in order to make the informed decisions in mathematics teaching to ensure improvement of mathematics achievement of the learners.

This consent form needs to be signed by you before beginning of any research activities in your class. Furthermore your learners and their parents will also sign the consent form to indicate their willingness to take part in this study and parents permission to allow their children to participate in this study. Please ask me should you have any enquiries related to this study

Thank you for considering this request

Gohelane Mathe Prof. Mosimege
M.Ed Student Research supervisor

## APPENDIX G: CONSENT LETTERS (TEACHER)

University of the Free State Faculty: Education

Grade seven teacher letter of informed assent
Research theme: “To explore the influence of chess games on the performance of senior phase learners in mathematics”.

I …… (teacher’s full names) teacher of grade seven learners of ……(name of school) give/do not give (circle that which is relevant) permission for my learners to participate in the above mentioned study and give my permission for the observations and interviews to be video recorded.

…… ……..
Teacher’s signature Date

## APPENDIX H: CONSENT LETTERS (PRINCIPAL)

University of Free State Faculty: Education Department: Mathematics Education

Principal's letter of informed assent
Research theme: "To explore the influence of chess games on the performance of senior phase learners in mathematics".

Dear Principal
I am currently completing my major dissertation as part of the requirements for my Master's Degree in Mathematics Education. This project is concluded under the supervision of Prof Mosimege of the University of Free State. With your permission, the research will be conducted in your school with grade seven mathematics class and will determine whether game of chess may improve learner's performance in mathematics. Your mathematics teacher will participate in this research by supervising a group of learners playing chess games. Attached please find the copies of consent letters that your grade seven mathematics teacher, parents and learners will receive.

Your participation in this study is voluntary. You are free to withdraw your consent to participate in this study any time during this study. If you decide to withdraw there will be no negative consequences to you or your learners. Participating in this research will not influence your learner's Mathematics marks.

The research process will include observations and interviews with grade seven learners of your school. I will observe your learners while playing chess then the interviews will be completed with a group of selected learners for this project. With your permission, learners, teachers and parents approval a tape recorder and a camera will be used in class in order to have the recorded pictures of this process and your grade seven mathematics teacher supervising learners while playing chess. After the process of the study the records and pictures of your class will be stored safely and will only be viewed by me and be destroyed after completion of this project.

On you or your teacher's request, I intend to share findings with your teacher after the research is completed because it might hopefully assist him in teaching of Mathematics. I will ensure everyone's confidentiality by keeping their identity hidden through using a pseudonym during data analysis and reporting of this research.

There are no known risks and/or discomforts related with this project. This study may improve mathematics learner's scores. The recommendations after the findings to this study will not only benefit the school and the district but will also benefit the province and perhaps the whole country in order to make the informed decisions in mathematics teaching to ensure improvement of mathematics achievement of the learners.

This consent form needs to be signed by the school before beginning of any research activities. Furthermore your mathematics teacher, learners and their parents will also sign the consent form to indicate their willingness to take part in this study and parents permission to allow their children to participate in this study. Please ask me should you have any enquiries related to this study

Thank you for considering this request

Gohelane Mathe Prof. Mogege Mosimege
M.Ed Student Research supervisor

## APPENDIX I: CONSENT LETTERS (PRINCIPAL)

University of Free State Faculty: Education Department: Mathematics Education

Principal's letter of informed assent
Research theme: "To explore the influence of chess games on the performance of senior phase learners in mathematics".

I …… (full names) Principal of ……(name of school) give/do not give (circle that which is relevant) permission for my school to participate in the above mentioned study and give my permission for the questionnaires, tests and interviews to be video recorded.

…… …….. …….
Principal's name Signature Date

SCHOOL STAMP

…… ……
Gohelane Mathe Prof. Mosimege
M.Ed Student Research supervisor

## APPENDIX J: FOCCUS GROUP INERVIEW QUESTIONS

FOCUS GROUP INTERVIEW QUESTIONS WITH SENIOR PHASE MATHEMATICS LEARNERS

NAME OF LEARNER

NAME OF RESEARCHER Ms G.E MATHE

DATE

PLACE KGATO PRIMARY SCHOOL

TIME 15H00

DURATION 30 MINUTES

FILE NAME

INTRODUCTION

My name is Ms Mathe. I am a student at the University of the Free State. This project is all about investigating whether the game of chess might improve the scores of primary school learners in mathematics. Please ensure that you only become the participant in this study only if you have signed your accent and parent consent form given by your teacher. The interview begin with an opening question, then seven questions which will take 30 minutes to complete.

Opening question: Talk about yourself (introduction, roles at school etc)

_____

_____

_____

_____

_____

INTERVIEW QUESTIONS

1. What did you like best about the chess lessons?

_____

_____

_____

2. What did you like least about the chess lessons?

_____

_____

_____

3. What is your opinion of the influence of chess games and your performance in mathematics?

_____
_____
_____

4. Which specific activities in Chess have you found to be useful when you solve mathematics problems?

_____
_____
_____

5. Chess involves deep level of thinking and prediction related to what your opponent will do before you make your own moves to pre-empt the moves by your opponent. How does this relate to how you solve mathematics problems?

6. _____
_____
_____
_____

7. When you compare a chess game top solving mathematics problem, what do you find similar in the process?

_____
_____
_____

8. When you compare a chess game top solving mathematics problem, what do you find different in the process?

_____
_____
_____

Thank you so much for taking your time for responding to the questions and being part of this project. Your answers to this questions will be kept confidential.

## APPENDIX K: OBSERVATION SHEET

OBSERVATION SHEETS WITH SENIOR PHASE MATHEMATICS LEARNERS

SCHOOL: _____

LEARNER _____

| No | Item | Observation Yes/No | Comment |
|---|---|---|---|
| 1 | Attention span | | |
| 2 | Movement | | |
| 3 | Quietness | | |
| 4 | Time taken to move pieces | | |
| 5 | Concentration | | |
| 6 | Problem solving | | |

## APPENDIX L: LETTER FROM LANGUAGE EDITOR

Michelle Woolley

WRITER EDITOR PROOFREADER TRANSLATOR

Bachelor of Library and Information Science: B.Bibl.
Reference & Research Librarian
Bachelor of Arts **Honours** in **Translation Studies and Editing**

Associate Member of Professional EDITORS' Guild (PEG)

# CERTIFICATE OF EDITING

This letter certifies that I have edited the Dissertation detailed below.

Title:

EXPLORING THE INFLUENCE OF CHESS GAMES TO IMPROVE PERFORMANCE OF SENIOR PHASE LEARNERS IN MATHEMATICS

Author:

EVELYNE GOHELANE MATHE

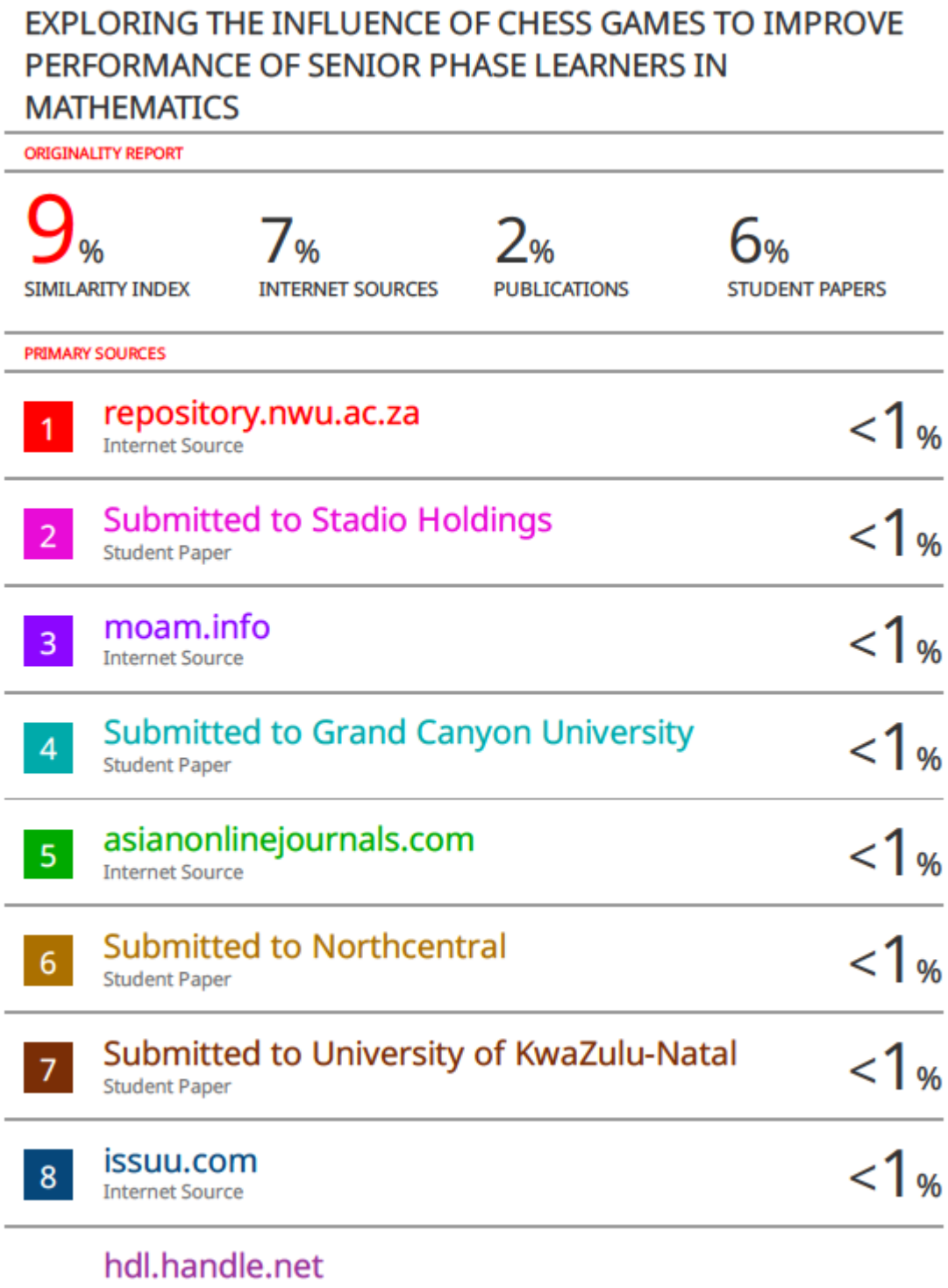
Regards
Michelle Woolley

Date: 13/10/2024

michellewoolley12@gmail.com
083 298 2077

Professional EDITORS Guild

**APPENDIX M: TURN IT IN REPORT**



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