Using Chess as an Educational Tool to Promote School Readiness in Historically Disadvantaged Schools in The West Rand

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Abstract

In this thesis a quantitative approach involving a quasi-experimental design was used to study the effect of chess classes on the cognitive and intellectual development of Grade R learners in Gauteng. The research comprised two interrelated stages, both with control and experimental groups but no randomisation.

In the first stage, chess instruction as a treatment factor was investigated in a standard Quintile 5, public school. A sample (N=64) was drawn from a single school, with two groups, an experimental group receiving chess instruction over a 40-week period and a control group not exposed to any chess instruction during this period. The groups were assessed at a pre and post level using the Junior South African Individual Scales instrument to determine whether the chess instruction had an effect on their intellectual development. A repeated-measures analysis of variance revealed statistically significant differences between the group means on the Performance intelligence and the Global intelligence scales, suggesting a positive effect of chess instruction on some aspects of cognitive development over time, but the magnitude of the effect was small.

In the second stage, the study was extended to investigate the practical application of a chess intervention in a developmental context involving groups of schools (control versus experimental) with a total sample size of (N= 122). The children were assessed using the multilingual Aptitude for School Beginners' group test to establish the effect of chess instruction on scholastic development, but a repeated, multivariate analysis revealed no positive interaction between chess instruction and group over time. A qualitative comparison between the two groups of schools suggests that the teaching environment was not homogeneous as in stage 1, but quite heterogeneous with regard to cultural aspects such as the language of tuition, as well as the teachers' ages, educational experience, qualifications, and working environments.

Evidently, in the second stage environmental variables had a greater impact on the children’s cognitive development than the chess instruction as such. It is recommended that future

research further explore the effect of environmental and school-based conditions in the investigation of the effect of chess on the cognitive development of young children.

Key Words: chess instruction, Grade R learners, schools, teachers, school readiness, cognitive and intellectual development, novice-expert shift, psychometric tests, transfer

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Chapter 1

General Overview

Chess is regarded as a highly visual, competitive, and sophisticated board game (or sport) of pure skill with a long tradition (Charness, 1991; 1992; Gobet, 2012; 2016). Kasparov (2017) posits that the precursor of chess, a game called Chaturanga, originated in India before the sixth century from where it moved to Persia and later to Europe. In the late Middle Ages, this cultural gamer or 'artifact' was played in the courts of Europe, and subsequently became popular worldwide. Chess has constituted a part of the school curriculum for more than 40 years in Russia where almost every household has a chess set and where chess is played at a very high level. Thus, in 2023, Russia had a record of 364 grandmaster titles, according to Sumeet Karthale (India TV News, 2023).

The game of chess is also relevant to researchers in psychology and education because itis thought to have links with academic subjects such as mathematics and computer science. Some research suggests that it may have a beneficial effect on the intellectual and cognitive development of children.

Chess, Backgammon, and Go are certainly the most researched and popular board games worldwide (Burgoyne, Sala, Gobet, Macnamara, Campitelli, & Hambrick, 2016; Gobet, 2016; 2017; Trinchero, 2013). Chess is of particular interest to researchers due to its complexity and significant cognitive and intellectual dimensions, coupled with widespread competitions, online platforms, databases of games, and the official Elo rating scale (1978; Waters, Gobet, & Leyden, 2002). This scale objectively quantifies the knowledge and skills of chess players and is used to measure the level of playing ability and expertise in the chess domain. Expert-level and novice chess players have been used as participants in studies on strategic thinking, memory, and expertise in cognitive psychology, cognitive neuropsychology, educational psychology, and computer science because chess ability and knowledge can be objectively measured and compared between players (Gobet, 2016; Simon & Chase, 1973).

In a number of research studies there have been indications that exposure to chess playing can help to improve school readiness as well as the academic, intellectual, and cognitive skills of young and older children, as measured on various psychometric tests (DuCette, 2009; Frydman & Lynn, 1992; Sallon, 2013; Sigirtmac, 2012; Sutton & Krueger, 2002). Furthermore, chess players outperformed non-chess players in cognitive skills related to intelligence in a meta-analysis carried out by Sala and Gobet (2016). However, not all the studies have revealed significant results after the learners had been exposed to chess classes. For example, in the studies conducted by Jerrim, Macmillan, Micklewright, Sawtell, and Wiggins (2018) and Pells (2016) the researchers did not find any evidence of improved academic outcomes one year after exposure to chess classes. Some researchers also did not find that chess classes had any effect on school performance differences between boys and girls, and there was also no clear relation between chess ability and socio-economic status (Chitiyo, Ablakwa, Akenson, Besnoy, Davis, Lastres, Littrell, & Zagumny, 2021).

Chess is often connected with giftedness in popular culture but the empirical evidence for this is inconclusive (Gobet, Campitelli, & Bilalić, 2014). Gliga and Fleshner (2014) conducted research related to this aspect, and found in a sample of primary school children that high intelligence does not necessarily predict success in a chess competition, but that the children who displayed resistance to monotony fared better in the competition than those who were less negatively affected by monotony.

Evidently many factors influence chess ability and the relationship between chess ability and cognition and intelligence is still relatively unclear. The aim of this research study is to shed more light on this relationship by investigating the effect of using chess classes as an educational tool to improve the scholastic performance and cognitive development of young children.

1.1 Chapter Overview

This chapter introduces the two-stage thesis, the theoretical framework in the chess and cognitive domains against the backdrop of the educational systems in South Africa. It includes the statement of the problem, hypothesis formulation, scope and limitations, conceptual framework, motivation and significance of the study; the clarification of concepts; and an outline of the remaining chapters in the thesis.

1.2 Chess as an Educational Resource for Researchers in Psychology, Education, and Stakeholders

The process of teaching chess to young children or beginners can be regarded as an instructional technique or tool that enhances various aspects of human cognition and learning due to the characteristics and principles of the chess game on account of the clear-cut outcome criteria and short-term feedback cycles in chess playing (De Groot, Gobet, & Jongman, 1996). Chess playing involves some informal processing of mathematical and logical concepts because players perform spatial visualisation to calculate the consequences of board changes based on possible move sequences (also see Whitehead, 1929). Thus, when children are exposed to chess playing, they master some aspects of conditional thinking and they develop memory skills to remember and assess the outcomes of opening and end-game strategies (Kennedy, 1998; Nunes, 1992).

Oberoi (2021) views youths of 8 to 17 years as being vulnerable because they may have underdeveloped levels of executive functioning. Everyone needs to think about and consider the effects or outcomes of their decisions before they act, which is important in daily life and is shown to yield far-reaching effects. Chess playing is viewed as a valuable method of intervention or tool by

Oberoi (2021) because it helps to improve the executive functioning of young players, with positive effects on their subsequent decision-making and working memory. Furthermore, certain researchers argue that chess functions as an instrument that helps to develop logical and deductive thinking skills because when moves are evaluated and planned, a chess player must select from different move options, and contemplate outcomes in a logical manner (Subotnik, 1993). In a similar vein, Lashley (2023) contends that chess playing nurtures educationally relevant higher-order thinking skills such as problem-solving and decision-making, context-dependent critical thinking, strategic thinking abilities, planning, inductive reasoning, spatial reasoning, and metacognition.

Due to its perceived cognitive and educational benefits, there is an interest, both in this country and abroad, in using chess as an educational instrument or remedy for poor education in schools (Luneta & Giannakopoulos, 2016). Links between the chess and education domains are:

- In both settings, visual information enhances learning in classrooms (Schneck, 2005).
- Through chess playing, the visuospatial and abstract symbolic thinking required in mathematics may be linked and chess playing could enhance the understanding of mathematics (McDougall, 2013, April 2).
- Peterson (2002) reports that many of the standards for mathematical reasoning in the United States of America reflect thinking and problem-solving skills associated with chess playing because when learners solve problems in mathematics and chess, they make use of various logical principles such as identifying relationships and calculating consequences. Learners and chess players also involve visualisation, pattern recognition, planning, and mental models in their thinking.
- When educators or trainers incorporate principles of mathematics during blended chess classes, this facilitates learning processes. Nonetheless, a variety of teaching methods

and materials are required to understand and develop knowledge in the two domains of chess and mathematics (Gobet, de Voogt, & Retschitzki, 2004).

- Mathematics and chess-playing are both ideal contexts for complex problem-solving and decision-making tasks that require a significant amount of time to solve. In complex domains such as chess, the acquisition and development of knowledge also requires much (deliberate) practice and effort to accumulate a vast amount of domain-specific knowledge and automatisms which enable learners to compete with one another on different platforms. The latter promotes mental alertness and elicits a high level of achievement (Campitelli & Gobet, 2008).
- It is possible that the newly acquired confidence gained when players improve in chess could transfer and exert a positive effect on their general cognitive development and such personal growth could also facilitate their adaptation to the demands of the educational environment.

Thus, it is evident that exploring and explaining the cognitive processes underlying chess playing is a potentially useful endeavour that may yield insights that could contribute to contemporary educational theory and practice (Jones, 1990).

1.3 Chess and Socio-economic Development in South Africa

South Africa is a developing country with a heterogenous population (60,414,495 in 2023) and twelve official languages, which places high demands on education (see Section 3.1.; see Janse van Rensburg, 2015; Worldometers, 2023). There are two educational systems, a well-functioning school system and a less well-functioning one, in South Africa, but a lack of educational progress in some areas as only 20% of public schools are functioning properly (Wills, 2023). Some of the cognitive developmental issues in South Africa (Section 3.6), relate to a lack of resources; low intellectual skills; language, learning, and critically thinking barriers amongst some young children; insufficient levels of school readiness in some learners, and also poor literacy, and insufficient numeracy skills (Albertyn & Guzula, 2020; Isaacs, 2012; Trinchero & Sala, 2016).

Garry Kasparov (2013), a former world chess champion, contends that using chess in education is an effective means to address poverty and violence and that it could counteract some of the negative effects of poverty prevailing in some of the areas where schools are located in South Africa. Moreover, numerous researchers contend that chess is a relatively inexpensive instrument that can be used to teach young children to acquire new skills, to enhance their cognitive development, and to foster problem-solving abilities in academic subjects such as science and mathematics (McDougall, 2013, October 8**;** Scholz, Ernst, Loeffler, Niesch, Schwarz, Steffen & Witruk, 2008). It is this use of chess as an educational tool that is the focus of the research reported in this thesis. The basic assumption is that exposing young preschool children in Grade R to chess instruction will facilitate the development of their cognitive and academic skills (Ericsson, 1988). Due to neuroplasticity, it is extremely natural for young children to learn; it is why they like to play. However, Robert Sternberg (Sternberg & Sternberg, 2012) contends that with guidance from adults and the necessary (educational) resources, they can improve even more, and may be able to perceive better, learn more, remember, and reproduce information better than they would have been able to do without such guidance (Vygotsky, 1997).

1.4 Theoretical Concepts and Themes

The research reported in this thesis is motivated by some of the educational and social factors explained above, and focuses on the relationship between chess, cognitive, and scholastic aptitude skills. The specific issue being addressed here is whether learning to play chess could exert an effect on the development of cognitive and school readiness skills of young children, as measured in the JSAIS or ASB scales. Various theoretical concepts and themes in the following sections are associated with the theoretical framework underlying the research conducted in this study. A few of the core concepts and themes are briefly described here and will be further discussed in the subsequent chapters.

1.4.1 Acquiring Expertise

The educational aim in complex scientific (knowledge-rich) domains such as physics, music, and chess playing is to enable learners to develop knowledge and understanding that will improve their problem-solving skills. Research on the acquisition of expertise in chess is useful in this regard, because understanding how players improve their skills in chess and become experts in chess, provide valuable insights into ways of assisting novices in developing similar skills, knowledge, and abilities as experts in various other fields (Malamed, 2009). Waters, Gobet and Leyden (2002) explain that, according to research in cognitive psychology, extensive practice is necessary to achieve expertise in knowledge-rich domains, such as the chess, because long-term learning experiences and knowledge develop over time.

Young children require considerable exposure to relevant information before they achieve competence and begin to demonstrate good problem-solving skills in a particular domain or area of expertise such as chess. This process of acquiring such expertise is called a *novice-to-expert* shift where, for example, young children begin with a random set of unrelated facts, small knowledge bases with an unorganised framework, ill-defined problem-solving skills and at times, they struggle to solve the problems and exhibit poor metacognitive abilities while they do not possess sufficient experience and background knowledge to engage in any long-term strategic planning (Bédard & Chi, 1992; De Groot, 1946; 1978; Persky & Robinson, 2017). The implication is that individuals move from a state of little proficiency in, for instance, chess playing, to one of competence or even expertise. In the domain of chess, achieving a high Elo rating (e.g. more than 2000) is a very lengthy process but any significant gain in this rating would be a manifestation of a (novice-expert) shift in chess playing strength and a gradual movement towards expertise in chess, possibly with concomitant positive consequences regarding other aspects of cognition (Gladwell, 2013). This occurs after extensive chess practice, as explained in Ericsson's (1988) theory of deliberate practice.

De Groot (1946; 1978) initially differentiated between experts and novices in exceptional memory or memory recall (Section 2.2.2). In many games and also in areas of science there is a prolonged learning process before the novice becomes competent in the domain, and this entails not only acquiring the relevant knowledge, but also improving memory and problem-solving skills. This learning process occurs in chess (Chase & Simon, 1973), bridge, and Go (Reitman, Nado, & Wilcox, 1978) to solve problems in physics (Chi, Feltovich, & Glaser, 1981), and in computer programming (e.g., Ericsson, Chase, & Faloon, 1980). In some of these domains (e.g., chess, physics, and music) studies of skilled memorisers have led to a theoretical account of the skill of the expertise known as skilled memory theory (Chase & Ericsson, 1982). The acquisition of these skills is difficult to explain at the neural level because parallel processing systems are involved, and the resultant activities are simultaneously distributed across various regions of the brain, implicating both inhibitory and excitatory neural processes (Bouchrika, 2024). Sternberg and Sternberg (2012) posit that at the cognitive level there are modular, domain-specific processes and also some fundamental, domain-general processes, but the underlying mechanisms are still unclear. Evidently, acceptable theories and models of chess expertise are still needed to explain the learning processes that occur when chess players become more skilled, and acquire chess expertise (Eysenck & Keane, 2020, p. 612; Sections 2.2.1 - 2.2.5).

Gobet (2012; 2016; 2017) posits that the field of expertise still faces some open questions and challenges such as the exact contribution of innate talent in the process of developing expertise and a lack of multi-disciplinarily interaction between researchers in different fields or domains of expertise.

1.4.2 Transfer

One of the aims in educational settings is to ensure that learners understand and apply what they have learned in one domain to other domains, situations, and contexts, and thus to transfer from one domain or academic subject to another, for example, from chess to mathematics, or from mathematics to physics, and physics to chemistry (Eysenck & Keane, 2020). This transfer of knowledge from one domain to another constitutes an important goal in both education and chess playing because any carry-over effect of knowledge across domains facilitates the learning process (Detterman & Sternberg, 1993, as cited in Sternberg & Sternberg, 2012). In this thesis, in both stages, young children in different schools are being taught to acquire a new skill such as chess playing, which is a complex board game, with the hope and expectation that some aspects of this skill will also make a beneficial contribution to their scholastic development.

Before learners are exposed to chess classes, there are various factors or requirements that chess instructors or facilitators should be aware of that could influence the extent to which transfer occurs and they should adhere to them to ensure that learners acquire some theoretical and practical knowledge or skills (Ericsson, 1988; Ormrod, 2006; Section 2.2.2). Thus, Ormrod (2006, pp. 271-274) elaborates on the learning processes underlying transfer by explaining that the assumption is that knowledge acquired in one educational domain may also be associated with acquiring skills in problem-solving, creativity in artistic thinking and ability, and critical thinking that could have positive effects in a variety of other domains.

The three requirements important in problem-solving in educational settings and learning are briefly that new material must be studied in depth; knowledge must be retrieved from long-term memory due to cues already stored in the working memory, and many opportunities for extensive practice must be provided (also see Ogneva, 2017). Furthermore, Peterson (2002) maintains that meaningful learning must be engaged in fully and learning of general principles must be shared by both domains, for example, in education and the chess domain. One should bear in mind that when non-expert chess players or learners are exposed to chess instruction, and chess practice on the chess board, at least some aspects of the associated teaching and learning process must be presented in a sufficiently general way that facilitates the transfer of some of the knowledge and skills gained to other domains. For example, if children also learn general memory and thinking skills such as how to remember opening moves and to contemplate the consequences of a move when they are learning chess, this would not only help them to achieve expertise in chess, but could also facilitate the transfer of some aspects of memory and thinking skills to other domains of knowledge (Gobet et al., 2004).

There are different types of transfer, positive or negative transfer and near and far transfer, but near and positive transfer is preferred by educators or instructors (De Corte, 2003; Sternberg & Sternberg, 2012; Section 1.5). For transfer to occur, there must be at least some links or connections between the domains, for example, between chess and education (Section 1.1). Barnett and Ceci (2002) contend that transfer takes place only when there is a strong similarity in the knowledge or skills required in two domains. Gobet and Campitelli (2006) posit that transfer from chess to other domains and vice versa is problematic in far transfer, and the more experienced or skilled a chess player is, the more problematic and restricted the transfer of this knowledge will be. The reason for that could be that the specialised knowledge that experts possess is partly coded as chunks of knowledge and this could lead to difficulty in transfer because the chunks involve pockets of information that have been specially coded for the specific domain of knowledge, namely chess in this case (Gobet, Chassy, & Bilalić, 2011).

Gobet and Campitelli (2006) also suggest that the human cognitive system operates with general mechanisms, but that the different types of skills and information required from the environment in different domains limit the possibility of transfer. These researchers also argue that many studies that report unsuccessful transfer contain serious methodological flaws. For example, investigations by Redman (as cited by Gobet, 2011) indicated that only three studies (Christiaen & Verhofstadt-Denève, 1981; Frank & D'Hondt, 1979; Fried & Ginsburg, n.d.) assigned young learner-participants randomly to the chess treatment group (Gobet & Campitelli, 2006). The take-home point is that for transfer to happen, sound methodological methods in studies must be employed (Section 3.8.3).

Transfer is not always positive. Haijian, Hexiao, Kunru, Lei, and Weiping (2011) reviewed transfer theories and effective instructional practices, and contend that a certain amount of learning is also unintentionally transferred to memory stores, and this may not be relevant to other domains (Gobet, 2016). One should also bear in mind that there is evidence of transfer in the ACT-R model, which was not predicted by Anderson (1996) (see Section 2.1.3). Hence, the conclusions that can be drawn about the transfer of chess expertise to other domains are often limited, especially in far transfer (Gobet & Sala, 2023).

The themes briefly discussed above, focussed on the broad theoretical framework in which the research in this two-stage thesis was conducted. Chess expertise, practice, and transfer of learning are crucial concepts in this study because the general postulation is that young children exposed to focused chess instruction will transfer some of the benefits of the theoretical knowledge and memory practice gained from playing chess to other aspects of cognition and intelligence. However, before explaining the study in greater detail, a few of the core concepts associated with the study are defined and described in the next section.

1.5 Clarification of Key Concepts

Some of the important constructs and concepts used in this study are explained below.

Automatic operations, a*utomatisms or processes* refer to “behaviour executed without conscious awareness”, which entails “to the ability to process information with little or no effort” (Colman, 2006, p. 70; Eysenck & Keane, 2020, p. 228). Moors (2016) notes that these “automatic processes are very efficient, because they have no capacity limitations” and they occur “in the absence of attention.” It seems as if there is “perfect coherence or consistency among the features”. The four key features associated with automaticity is: there is a “lack of conscious awareness”; it is “efficient and fast”, and it is “goal- unrelated or goal-uncontrolled” (Moors, 2016, p. 228; Eysenck & Keane, 2020, p. 228).

Deliberate practice and chess instruction: Ericsson and Ward (2007, as cited in Eysenck & Keane, 2020, p. 612) contend that “deliberate practice over a period of many years is essential to become an expert in a given domain.” “Ten years (10 000 hours) of deliberate practice is required to achieve expertise” (see also Gladwell, 2013).

In this study, the term *chess instruction* is used when referring to Grade R learners as they are not yet able to read or write, which is also an aspect of deliberate practice.

Expert or chess expert: Previous research (Campitelli & Gobet, 2008) indicates three different kinds of chess players, namely masters, as the best; experts; and intermediate players (also see Gobet, 2017). A *chess expert* is the term used throughout the thesis when referring to the highest-skilled player in the chess domain, and experts are contrasted with novices in terms of the level of knowledge and skills in chess.

Expertise refers to “the high level of knowledge and performance in a given domain that an expert has achieved through years of systematic practice”, namely the chess domain in this thesis (Eysenck & Keane, 2020, p. 808). It can also refer to “superior skills or achievement reflecting a well-developed and well-organised knowledge base” (Sternberg & Sternberg, 2012, p. 532).

Eye-walk refers to a learned (automatic) “action or sub-routine performed by expert chess players during the process of perception in problem-solving”, whereby chess players roll their eyes continually, “in a clockwise fashion during active organised field searches to detect patterns to act upon them (De Groot et al., 1996, pp. 76–78).

Historically disadvantaged schools refer to schools designated to black learners in the Apartheid era, according to Xaba and Mofokeng (2009). These schools are mostly located in poverty-stricken areas, mostly in townships, rural, and farm areas, and often face challenges relating to resources acquired by delivery, and they have little or no internet. They are predominantly characterised by poor educational infrastructure and resources, but some schools manage to overcome these hardships, especially due to principals with good entrepreneurial and leadership skills.

Metacognition: Eysenck and Keane (2020, p. 813) define this as “one’s own cognitive processes and likely level of performance.”

Novices and amateurs are chess players who can play a game of chess according to the rules but they are completely overshadowed by experts who have superior knowledge in chess-playing. The process of developing from a relative novice to an expert player is called the ‘*novice-expert shift’* according to De Groot (1946; 1978; see also Ericsson, 1988).

Power of Law of Practice (motor): This law in cognitive psychology captures a "relationship between practice and performance in perceptual-motor skills and describes the learning curve associated with specific cognitive skills" (Eysenck & Keane, 2005, p. 421). This law implies that when a chess player practice for hours and even years, a "general improvement in reaction time of the skill, where the player becomes quicker at finding accurate moves, is captured in terms of a monotonically decreasing curve" (Logan, 1988; Gladwell, 2013).

Skill acquisition refers to "the development of abilities through practice to increase the probability of goal achievement" (Eysenck & Keane, 2005, p. 564).

Transfer refers to "any carryover of knowledge or skills from one problem situation to another"; it can be either positive or negative (Sternberg & Sternberg, 2012, pp. 462; 537). It is also described as the "broader phenomenon of any carry-over of knowledge, training, or skills that affect, or is applied when learning or performing in another situation in problem-solving" (Detterman & Sternberg 1993**,** as cited in Sternberg & Sternberg, 2012).

Positive transfer occurs "when the solution of an earlier problem makes it easier to solve a new problem", or skills learned in one situation transfers to different contexts, and thereby affects learning in another situation (Barnett & Ceci, 2002; De Corte, 2003**;** Sternberg & Sternberg 2012, p. 462).

Negative transfer, on the other hand, "occurs when solving an earlier problem makes it harder to solve a later one" such as prior struggling in mathematics or in chess playing, which will hamper problem-solving (Ormrod, 2006, p. 269).

Visualisation is regarded "as part of an associative process which leads to skill at chess and is described as the summation of many learned skills and many previous steps" (Fine, 1965, p. 364–369).

Visuo-spatial thinking: Ormrod (2006, p. 9) defines "*visuo-spatial thinking* as the ability to imagine and mentally manipulate two- and three-dimensional figures". This kind of thinking appears to be related to some aspects of mathematics achievement or notation in chess playing, although the nature of the connection is not clear (Bocchi, Guarglia, Matteoli, Palmiero, & Persichetti, 2024; Friedman, 1995).

Working memory (WM) refers to "a limited-capacity system used in the processing and brief holding of information" (Eysenck & Keane, 2020 p. 823).

1.6 Problem Statement

1.6.1 Aims

The study investigates the effect of chess instruction on the cognitive and associated scholastic development of young Grade R children.

The research described in this thesis is based on an overarching research project involving two stages. The first stage (S1) focused on a (convenience) sample of young Grade R children drawn from a single Quintile 5 school, and this part of the research was initially described in Basson (2015). The description and research results of this stage are presented again but the data is re-analysed using a different approach and the text is not merely repeated from Basson (2015) but re-written to fit the current research study. This stage of research was undertaken with children in a former model C school and the sample (*N*=64) consisted of two groups of Afrikaans speaking children who received instruction in chess after their parents enrolled them to chess tutoring, the experimental group, and another group, functioning as a control group that did not receive any chess instruction. The learners in the control group were included in this group after their parents consented to participating in this research investigation. It was not possible to control chess playing after school, because young children could have taught another friend/playmate, how to play chess, but they usually have a variety of games to play, therefore it would not have been the most obvious game to play due to its difficulty. After 40 weeks, these groups were compared utilising the Junior South African Intelligence Scale psychometric test to establish whether the chess intervention had an effect on the intellectual development of the children during the stated period. This study functioned as a prelude to the second stage and was conducted as a type of proof of concept to determine whether chess instruction could exert an effect on cognitive and scholastic development of children in a context where most nuisance variables could be controlled.

The second stage (S2) is the main focus of the current research and in this part of the research the focus was extended to a *no-fee* developmental context. This stage investigated the practical application of chess as an educational tool in an environment where environmental, school and teaching variables play a much more significant role than in S1. In S2, chess classes were offered at two schools, the experimental group, and one other school functioned as the control group where the children did not receive any chess lessons at school. Afterwards, both groups were tested on a school readiness test, the Aptitude Tests for School Beginners, to determine if the chess classes had any effect on the scholastic development of the children over a 20-week period. This stage was much more exploratory than the first stage, and many systemic variables could have played a role such as the school, the teacher, and the socio-economic context of the developmental schools.

The main purpose of this thesis is to present the overall empirical study, and both stages are therefore described, even though S1 mainly comprises historical data. The primary aim of the study is therefore an investigation of the potential educational benefits (or no benefits and no chess tutoring in the control school) on school readiness or preparedness of two groups (control and treatment groups) in two contexts, a model C Quintile 5, school in Pretoria, and then a developmental environment involving three schools, which are no-fee schools, situated in the West Rand area of Gauteng (Section 3.1.1).

The research in both stages aims to explore the effects of chess on cognitive and scholastic skills, as well as intellectual development, on all the learner-participants in a former model C and developmental schools, after exposure to a receptive year. It will be measured by two different psychometric tests in this thesis. Different factors will be explored.

A second aim was to assess if the performances of the learners (as reflected on the teachers in the three schools) in S2 improved significantly over time and if there were differences between the (learners in the) classes after the school environments were compared with one another.

Lastly, another aim was to evaluate the use of chess playing as an educational tool in historically disadvantaged schools. Research objectives guide the steps of the research process, and are stated in the next section.

1.6.2 Research Objectives

Objective 1: To assess the relationship between cognitive and scholastic development and the time variable in the control and experimental groups, and in the schools included in the two stages. Two measuring instruments (the JSAIS and the ASB) will be used to determine a possible relationship between these variables, scholastic development and (over) time.

Objective 2: To determine the impact of exposure to chess tutoring on the learners in the experimental group and assess a possible relationship between chess tutoring (an independent variable), and cognitive development, intellectual skills, and school readiness.

Objective 3: To examine whether there is a relationship between the ‘age’ and ‘time’ (independent) variables at a post level, as determined by the JSAIS and ASB. To explore if the ‘older age group' (referring to learners who turned 5 before the end of June in the Grade R's calendar year) score significantly higher on the measuring instruments, at a post level.

Objective 4: To examine whether there is a relationship between the 'gender' variable and 'time' variable, as evidenced by boys obtaining higher scores on the JSAIS or ASB over time in this category.

Objective 5: To examine differences between 'schools, classes and teachers' (independent variables) at a post level, on the learner-participants' performances as evidenced on the two psychometric tests.

1.6.3 Research Problem

The research conducted in this thesis is framed within the constructs, themes, and general research context described in the previous sections. These themes and constructs essentially define the theoretical framework underlying this study. Based on Basson (2015), this research problem addressed in the first stage of this thesis is, whether a certain amount of chess playing will affect intellectual skills (as evidenced in the Junior South African Intelligence Scales) of Grade R learners. In the second stage of this study, the following research problem addressed whether chess playing and chess instruction will affect scholastic aptitude skills and cognitive development (as evidenced in the Aptitude Tests for School Beginners) of very young children in S2 in this current investigation.

Thus, the positive influence that chess playing brings to bear on the school-readiness skills of Grade R learners was investigated in S2. More specifically, the study investigated whether there was an accelerated development of specific aspects of cognition and (scholastic) aptitude skills (in ASB) in a group of young children exposed to chess instruction, compared to another group of children who did not receive such instruction. Moreover, the performances of 'older learners' on the ASB will be compared to 'younger learners', as well as the performances of boys versus girls at a post level, and learner-participants performances in different schools and classes.

In the next section, the research questions are posed; the hypotheses will be formulated and the significance of the study is briefly discussed with an emphasis on the more exploratory Stage 2 of the research.

1.7 Research Questions Pertaining to S2

RQ1**:** What is the impact of time when young Grade R children are exposed to a Receptive year, at a post level? Were the schools and teachers impacted differently over time? There were 66 learners in the Sepedi school, 20 in the Setswana school and 30 Grade R learners in the English school. In the Sepedi school there were 25 learners in the A1 class, 19 learners in the A2 class and 22 in the A3 class (see Table 5.8).

RQ2: What will the impact of chess playing be in the treatment or experimental group, after 20 weeks (or 40 weeks in S1) of chess classes over time? Will there be a significant difference between the control (66 learners) and experimental (50 learners) groups in favour of the chess group, after exposure to 10 hours, or 20 hours in S1, of chess instruction? Will the experimental group fare significantly better than the control group at a post level? Is there a relation between the group factor and the chess factor (over time)?

RQ3: Will the older (+5) age group display higher scholastic aptitude scores or intellectual scores (on the ASB and JSAIS) than the younger (-5) age group, at a post level? Will there be an interaction between both age groups over time, between age and time factors?

RQ4: Will the males (52 boys) in the gender group display higher scholastic aptitude scores (as evidenced on the ASB and JSAIS in S1), than the female (64 girls) gender group afterwards? Will there be an interaction between these gender groups over time?

RQ5: Will there be significant differences between the schools in stage 2 at a post-level? There was only one school in S1. Will the English and Setswana schools in the treatment group fare significantly better than the control school (Sepedi school) on the ASB (as represented by the learner-participants' mean scores) at a post level due to chess exposure? Furthermore, will there be significant differences between the five classes and/or teachers in five classes (in three schools)?

In Stage 1, the four research questions (H1-H4) were tested using one-way ANOVA (GLM 1) and MANOVA with repeated measures on different factors, in a mixed design of within and between factors. The five research questions (H1-H5) in Stage 2, were tested using different *t*-tests, parametric and non-parametric tests, one-way ANOVA (GLM 1) and MANOVA with repeated measures (GLM 3) on one factor, at a post-level after completion of the Receptive year. A mixed design with two between factors and one within factor was used with the repeated measures.

1.8 Formulation of Hypotheses in S2

In the next section, hypotheses are formulated for testing in Stage 2 in the current study.

1.8.1 Hypothesis 1 (H1)

It is hypothesised that both groups (the control group and the experimental group) will exhibit improved cognitive development (as reflected in the Aptitude Test for School Beginners) during the period in which the research was conducted.

1.8.1.1 Rationale. Piaget posits that cognition and cognitive abilities of children improve when they explore and discover aspects of the world (Section 2.2.1; Inhelder & Piaget, 1958). The learner-participants in the current study varied in age (from four and a half to six years during the period of testing), which includes an age group of (a few) learners younger than five years and learners older than five years (-5 and +5), and both age groups were mostly in Piaget's (1980) pre-operational stage. Furthermore**,** young children of these ages and in Stage 2 differ from one another regarding biological characteristics and nurture effects (namely, stimulation at home, at school, and in the environment), but due to the characteristics of biological maturation, neural plasticity, malleability, and an enriching educational environment, it is believed that all the learner-participants would display improved cognitive development, as exhibited in the global ASB. Furthermore, Vygotsky's (1997) sociocultural developmental theory is also applicable, because this theory asserts that the cognitive development and learning ability of a child can be guided and mediated by their social interactions with significant others such as parents and teachers. Lastly, according to Eysenck and Keane (2020), activation in the brain of a child occurs when they are exposed to new learning material, for example, in Grade R, during a reception year. However, if children are not exposed to new learning material, synapses will die off (Grantham-McGregor, Cheung, Cueto, Glewwe, Richter, & Strupp, 2007).

1.8.2 Hypothesis 2 (H2)

It is hypothesised that by the end of the school or calendar year, there would be a significant difference in the mean scores on the ASB at the post-test condition between the C and E groups.

Furthermore, the chess group would display higher ASB mean scores than the C group after being exposed to 20 weeks or 10 hours of chess tutoring, at the post-test and the treatment group would confer a cognitive gain. Hence a significant (in) between-group effect would be observed on the ASB scores of the experimental group.

1.8.2.1 Rationale. It is a very important question whether there are any positive carry-over effects after exposure to chess instruction to other disciplines, for instance, to assess school readiness in educational environments; this is also central in this thesis.

Nonetheless, findings in a study undertaken with adults as the participants (Basson, 2015; Grabner, Neubauer, & Stern**,** 2006) indicated that there was a statistically significant improvement in the scores of chess players in the global-general-intelligence score or in academic tests, and subsequently, transfer of learning occurred. Many other studies reported positive effects (or transfer) from chess playing to cognitive or academic subjects in young children (Doll & Mayr, 1987).

According to many researchers, namely Ericsson (1988; see Section 2.1.2) and Anderson (1990; 1996) (see Section 2.1.3), exposure to chess playing can result in the acquisition of expertise after prolonged chess practice.

1.8.3 Hypothesis 3 (H3)

It is hypothesised that at the post assessment, there will be a statistically significant difference in the two age groups among the Grade R learner-participants; the older learners (+ 5 years) will do significantly better than the younger Grade R learners (- 5 years) at the post-test at the end of the school year.

1.8.3.1 Rationale. A few of the learner-participants were four-and-a-half years old at the beginning of the school year, and they were much younger than the other learners who turned six in the same year. All the learner-participants in the current study were at Piaget's pre-operational stage at the beginning of the school year (Piaget, 1980/1952). It is possible that the older learners could have been more logical in their thinking than the younger learners and thus performed better in class when assessed on the ASB. These young children could also differ from one another pertaining to the characteristics of biological maturation, neural plasticity, and malleability (also see Gesell, 1940). Thus, it is posited that all the learner-participants will display improved cognitive development as exhibited in the global ASB at a post-test but the older learner-participants will fare significantly better than the younger Grade R learners, as in the ASB.

1.8.4 Hypothesis 4 (H4)

In this thesis, it is hypothesised that, at the post-assessment in the relevant period, there will be a significant difference between the ASB mean scores of the boys and girls. Furthermore, the boys will display higher SR scores than the girls at the second assessment or time point.

1.8.4.1 Rationale. There could be many reasons for this hypothesis. There is still a general belief that male dominance (patriarchy) exists in many professions such as mechanical engineering and computer science in South Africa and worldwide (Adani & Cepanec, 2019; Ananthaswamy & Douglas, 2018; Friedman, 1995; Sala & Gobet, 2016). Therefore, people in general tend to assume that males are smarter than females in some technical domains. However, both research and practical observations now suggest that there may not be any real significant differences between the two genders in chess ability, scientific aptitude, or intelligence. Lastly, in the educational setting, boys are considered to be more active in class and they would acquire greater attention or guidance from teachers; hence, teachers tend to react differently to boys in class (McDevitt & Ormrod, 2013).

1.8.5 Hypothesis 5 (H5)

In the current investigation, it is hypothesised that there will be significant differences amongst participants (learner-participants, as reflected on teacher-participants) in the relevant no-fee schools, classes, and teachers, as well as a different 'order of performance' between the different schools, classes, and teachers (and participant-learners) in the current investigation. Moreover, the two schools in the treatment groups will display significantly higher mean ASB scores, after exposing the learner-participants to 20 weeks of chess playing.

1.8.5.1 Rationale. Piaget posits that cognition and cognitive abilities of children improve when they explore and discover aspects of the world (Inhelder & Piaget, 1958). Therefore, one will expect the treatment schools to do significantly better than the control school based on the ASB. It is also hypothesised that there will be differences amongst the five teachers in both groups, because the teachers in these different schools differ in various ways. They differ in age, the developmental stages they reside in, years of teaching experience, and of years' experience in education, not to mention the differences between the no-fee schools and 'well-functioning or rich' schools, plus the environments they reside in (Bronfenbrenner, 1979; Mahn & John-Steiner, 2012; Vygotsky, 1997).

Furthermore, young children of these ages and at this stage not only differ from one another regarding biological characteristics and nurture effects but also due to the characteristics of biological maturation, neural plasticity, malleability, and an enriching educational environment. One must remember that development can occur in leaps and bounds, not uniformly (McDevitt & Ormrod, 2013; Gesell, 1940). Thus, it is believed that all the learner-participants will display improved cognitive development as exhibited in the ASB but the E group will fare better than the C group in Mamelodi (Anderson, 1990; 1996; Ericsson, 1988).

1.9. Motivation and significance of the Study

In this section the two different concepts, motivation (intrinsic and/or extrinsic motivation), and significance of the study are briefly discussed. Intrinsic participation in research entails the pleasure of gaining more knowledge as a keen or life-long learner or because one likes a new experience such as a new degree. Extrinsic or external motivation refers to a reward such as required for career development, or a degree with more professional benefits, or because the job requires it on different levels. It could be for a new post or a present post when trainers tutor chess to young children. However, for example, some learners or chess playing of some chess players do not improve after being exposed to chess lessons for a certain period (as in the case of the Stage 2 study), for unknown reasons (see Pells, 2016). Hence, when conducting a study such as this, the purpose is to augment both one's personal and the existing professional knowledge in the domain concerned, which of course is chess in this case (Hatmi, 2023).

In the S1 study, this researcher investigated chess instruction as a treatment factor in a 'rich' school. The sample (*N*=64) consisted of two groups, an experimental group of Grade R learners receiving chess instruction over a 40-week period and a control group that was not exposed to any chess instruction during this period at the school. The two groups were assessed at a pre- and post-level using a psychometric intelligence test. Results revealed statistically significant differences between the group means on the Fluid or Performance scale and Global intelligence scales, suggesting a positive relation between chess instruction and some aspects of intellectual development over time, but the magnitude of the relation was small in a convenience sample with no randomisation.

When this researcher was asked to adapt an existing Grade R Chess curriculum for a chess initiative in Gauteng, the opportunity arose to investigate chess instruction as a treatment factor in different educational developmental schools. The S1 and S2 study will contribute to academia, but also to different fields or domains. It will add to the number of studies of children, which are lacking or displaying inconsistent results in the investigation of putative chess-effects on cognitive, scholastic aptitude, and intellectual development in South Africa, and worldwide (Hatmi, 2023).

With this current study, contributions (and guidance) are also being made to cognitive science, education, the chess domain, and even industry. Of great importance in knowledge-rich domains (as in this thesis) such as chess playing, the knowledge gained could guide many researchers, chess trainers, curriculum writers and psychometric tests developers, in different fields (Hatmi, 2023). Subsequently, more successes at hand can follow, and more researchers can become life-long learners in the world (Malamed, 2009; Persky & Robinson, 2017).

It will also contribute to the number of reliable studies due to the two studies being conducted in two stages (S1 and S2) in different environments with the inclusion of a qualitative comparison of teachers in three schools (see also Gobet & Campitelli, 2006; 2007). It will also add to studies on children (currently with inconsistent findings), because the studies in S1 and S2 differed from one another for valid reasons; for example, chess playing took place in two different educational environments, and the different results were due to environmental reasons; thus, no inconsistency was reported (Campitelli, Bilalić, & Gobet, 2014; Frydman & Lynn, 1992; Gliga & Flesner, 2014).

This study also contributed to *transfer*, an unresolved phenomenon, namely *far transfer* in S2, when no relation was revealed between chess instruction and the time factor. Furthermore, in this study, methodological and theoretical gaps were revealed, and prospective researchers can contribute in many ways by norming participants again in some South African measuring instruments. New research, as in this study, can be communicated to relevant parties and changes can be made to the industry in an educational setting and in the economy. For example, if Grade R teachers are in possession of only a one-year Early Childhood Diploma and they still study part-time, additional tasks are expected from them, namely chess tutoring or serving and supervision during mealtimes. It may thus be better not to require the Grade R teachers to present chess tutoring classes, but to rather employ chess trainers for this, or to expose the learners to chess only in higher grades.

Lastly, according to Laudan (1978) outcomes in this current study, can add to the existing body of psychological theories in the relevant fields, and more answers can be found to uncertainties about phenomena that either have or have not occurred as well as to refute untruths.

1.10 Research Methodology

The research methodology associated with the study is embedded in a quasi-experimental design where the treatment variable was manipulated and no randomisation took place (as in the study in S1), because a non-probability convenience sample was already in place when learners were assigned to chess tutoring (Section 4.1.1). Moreover, a mixed-method design was used in both studies or stages. The JSAIS and ASB were administered twice (in S1 and S2), once prior to exposure to chess instruction as a baseline (at a pre level) and once thereafter (at a post level) at the end of the relevant periods. In S2, a qualitative comparison was made between the five teachers in the three schools. Questionnaires were handed out to the parents in (S1 and S2) but the return of these documents was poor, thus this was not pursued (see Appendix C).

The research questions in both studies (S1 and S2) were tested by making use of the relevant statistical tests and analyses.

1.10.1 The Variables Created for the Purpose of Data Analysis in this Current Research Study (in S2)

The following variables are created for the purpose of data analysis in this thesis:

- *Treatment* or *chess instruction* as an independent variable (with two levels, no treatment or 10 hours' treatment);
- *Groups* as an independent variable (the experimental group and the control group);
- *Gender* as a categorical (independent) variable for this study (boys and girls);
- *Age* as an independent variable (-5 and +5 age groups), where the 'younger learners' turned 5 at the end of June in their Grade R year, and the 'older learners' turned 6 during their Grade R year;

- *School readiness and scholastic aptitude development* (as represented by mean scores on the global ASB) of two groups, is a dependent variable of the two groups;
- *Time* as an independent variable (at two levels, namely the pre-test condition at the beginning of the year and onset of the investigation and the post-test condition or post level at the end of the school year).

The treatment variable, chess instruction, is also a categorical variable because, in the two different groups, a control group was not exposed to chess instruction, no variables were manipulated, and the experimental group received chess instruction. The groups variable (C and E), includes the (three) ‘schools variable’. The dependent or outcome variable ‘scholastic aptitude’ is a continuous, interval scale variable measured on the full, multilingual, ASB. This group test has eight different subtests such as perception (thus measuring perceptual aptitude), spatial test, reasoning test, numerical test, gestalt assessing test, coordination test, visual memory, and verbal comprehension as in verbal aptitude (Section 4.1.2.5).

Furthermore, the gender variable is a categorical variable and in this research investigation, refers to boys or girls and lastly, the age variable is also an independent variable with one group consisting of younger children and another group of the older age group. In this study, all the groups and sub-groups (C and E, schools, age groups and gender groups) display significant relations with the time factor, when learners were assessed on the ASB at a post level.

1.10.2 The Method and Procedure

The sampling process in both groups in both stages was not randomised but rather, a non-probability, convenience sample, with less control over nuisance variables. This was the case because all the learner-participants in the treatment group were due to receive chess tutoring in the relevant time period, because in S2 the young children formed part of (all) the schools that would receive chess classes as part of a social upliftment programme in the West Rand in a commercial endeavour of businessmen in the area. In the S1, the parents of the learners subscribed them to chess classes and that was also a convenience sample.

The control group in a different region was included in the research study in S2. Both groups were assessed on the ASB at a pre-level, to establish a baseline for the research and at a post-time level, as in a study of Jerrim, Macmillan, Micklewright, and Sawtell (2018), in Bangladesh. A pre-program baseline test of chess knowledge was assessed at a pre level, which indicated that the majority of the learners did not know how to play chess, before being exposed to it. Needless to state they were assessed after being exposed to 10 hours of chess training**.** The treatment group in S2 received 10 hours of chess tutoring, mostly by means of demonstration, and the control group was not exposed to chess classes at a school.

1.10.3 Instruments Used in the Current Study

The following instruments that were used to obtain data in this current study, were the following:

The Aptitude Tests for School Beginners (see Section 4.1.2.4) to assess the school readiness mean scores of the young children at two time points during the relevant period; and a questionnaire containing strict demographical information needed in this research investigation, were filled in by the chess facilitator and educational staff, for example, the principals of the three schools and the five teachers in these developing schools. Anonymity was maintained (see Section 1.8.5; see Appendix C).

When the treatment group in the study was assessed in a practical chess activity during the eighteenth to the twentieth week of chess exposure, it was executed in a manner that fostered a learning experience. In other words, when learners made mistakes, verbal feedback and guidance were given to learners/players, and they were afforded opportunities to correct the mistakes as experienced in chess playing, which took time (Section 4.1.2.3.1).

1.10.4 The Statistical Analyses Employed in this Current Research Study

In this study, the following statistical analyses were included: descriptive analysis, various parametric and non-parametric tests, one-way analysis of variance, repeated measures ANOVA with repetition, and two-way (multivariate) analysis (MANOVA). A quasi-experimental design was selected to garner and analyse the data, partly because full control could not be extended to all the nuisance variables but mainly because a convenience rather than a purely random sample was used (Field, 2018, pp. 19 - 21). The influence of chess instruction on the development of the intellectual abilities of the young children was explored using a 2X2 repeated-measures analysis, with two groups who were analysed (over time) at two different time-points.

1.10.5 Ethical Aspects

Permission to conduct this investigation was obtained from all the relevant parties such as the Gauteng Department of Education (GDE), the school governing body or principals of the primary schools in Gauteng, the University of South Africa, and informed consent was obtained from the parents and legal guardians (Section 4.1.1.6). The psychometrist administering the psychological tests had to comply with all the requirements of the Health Profession Council of South Africa (HPCSA) and underwent all the necessary training (and accumulated ample experience) for the administration of the JSAIS and ASB psychological tests.

All the above requirements had to be concluded to ensure that assessment practices were executed professionally and ethically according to the 1999 Ethical Code of Professional Conduct (Foxcroft & Roodt, 2005, p. 116). Parents of the prospective participants were informed about the purpose of the pre-planned, intended research, in a meeting with the school principals and school governing bodies. The forms were placed in the backpacks of the children for the attention of their parents and legal guardians. The rights of the learner-participants were stipulated in writing in the consent forms to inform the parents and legal guardians about the relevant matters and rights of the learner-participants when giving consent for young children to participate in research studies (see Appendix A).

1.11 Contribution of the Research on Chess

In this thesis, the impact of chess tutoring on the cognitive, intellectual, and scholastic skills of young children in developmental and 'well-functioning' schools were investigated. Some gaps and limitations were identified before the research commenced, and it was subsequently determined that these, as well as environmental aspects, contributed significantly to the research results.

There is a lack of reliable research conducted on young, five- to six-year-old children, in the currently available research on the putative positive effects of chess on cognitive development. This is the case both in the South African research literature and worldwide. Furthermore, in the research that is available, the findings relating to the benefits of chess on cognition are inconsistent because some factors, for example visuospatial skills, are important in young developing children but not in adults (Frydman & Lynn, 1992; Campitelli et al., 2014; Gliga & Flesner, 2014). Hence, the two-stage investigations in this current research investigation will add to the pool of studies of young children; it will contribute to more reliable studies and it could reduce some inconsistency in child studies, especially when different environments are compared to one another (Gobet & Campitell, 2006). Furthermore, guidance and/or feedback can be given to professional people in different domains, for example in education departments, the chess domain (to chess trainers and chess curriculum writers), and business laymen, after exposing learners to different periods of chess instruction and assessing them on specific measuring instruments (also see Hatmi, 2023).

Young developing children in South Africa and in other countries will benefit more when research studies are being done so that learning can be optimised. The parents in S1 subscribed their children to chess classes, probably to improve their academic or intellectual skills, and the purpose of exposing young children in no-fee schools to chess classes served as a type of social reform of upliftment, specifically of interest for the businesses (covering/sponsoring the costs of chess training in certain schools), leaders, and educators worldwide. Furthermore, in an investigation, various factors can be investigated and improved, such as the selection and sampling used in research studies. Hence, in future studies and in improved chess training for children, limitations can be decreased and control exerted by the researcher(s) could be increased.

Even though there are some weaknesses in this research study the findings in the research may contribute to the body of knowledge/current literature in this respect by addressing several gaps in the current status of research on this topic and by providing some guidance for future studies.

1.12 The Thesis Structure, an Outline of the Remainder of the Thesis

Chapter 2 furnishes the literature review of relevant constructs and discussions of various theories relevant in human and cognitive development. This study falls within the framework of the information processing paradigm in cognitive psychology and the relevance of this approach to explain how expertise develops, is discussed. The effects of chess instruction on cognitive and intellectual development are also explored in this chapter, as well as a discussion about the possibility/existence of an 'ideal time' to offer chess instruction to young children.

Chapter 3, a theoretical chapter, discusses the socio-developmental and cognitive developmental issues at some schools in South Africa, followed by a discussion of school preparedness in young children, and a comparison between the teachers in the control and experimental groups (in their surrounding school environments) in poverty-stricken areas with less resources. Thereafter, the transfer between domains obtained in chess playing and chess as an instructional instrument, concludes Chapter 3.

In Chapter 4, the methods used for data collection are reported, which includes the research design, sampling, and data collection methods as well as the ethical aspects thereof. The presentation of chess instruction to the treatment group is discussed briefly.

Chapter 5 reports on the results of the fieldwork in the empirical investigation that took place in two stages as well as the data profile and statistical methods used to obtain the results.

In Chapter 6, the main implications of the findings obtained in the study are discussed. The results are related to the literature and theory in the chess domain and thereby contribute to the existing knowledge in this field. The value and limitation of the study are also briefly discussed. This chapter also discusses the conclusions drawn as well as the recommendations and suggestions regarding future research, the implementation of the findings, and policy implications.

Chapter 2

Literature Review: Chess, Cognition and Cognitive Processes

Chapter 2 reviews and discusses some general research on the relationship between chess, cognitive ability, and intelligence with the aim to present a theoretical context for the specific issue addressed in this current two-stage study. It also considers whether chess playing can foster cognitive and intellectual development and subsequently enhance school-readiness and intellectual skills in Grade R learners in a former model C school and in certain no-fee schools (Eysenck & Keane, 2020, pp. 37 – 39). Not only is human cognition a complex phenomenon but cognitive processes, perspective taking and chess playing as a boardgame coupled with Go are also complex (Sternberg & Sternberg, 2012). Therefore, theories of expertise are first discussed followed by theories of human development. Thereafter, the chess and the cognitive dimensions of expertise, theories of intelligence, and transfer are also considered.

2.1 Theories in Chess Expertise

The educational aim in complex scientific domains such as music, physics and chess playing is to enable learners to develop knowledge and understanding that will improve their problem-solving skills. In the next section, various theories of Chess Expertise are discussed.

2.1.1 The Skilled Memory and Expertise Theory: Mechanisms of Exceptional Performance

Ericsson and Polson (1988) posit that after experts have acquired exceptional skills after prolonged chess practice, there are fundamental differences between some of their cognitive and memory abilities and those of novices (De Groot, 1946; 1978; Persky & Robinson, 2017):

The semantic networks in experts are more elaborate than in the brains of novices.

There is quicker and more direct interaction between working memory (WM) and long-term memory (LTM).

Information is more easily encoded and stored into long-term memory by experts (Ericsson & Kintsch, 1995).

Lastly, another difference can be added. According to Guida, Gobet, Nicolas, and Tardieu (2012), experts make use of different brain regions compared with novices when performing working memory tasks. Novices make use of activation in prefrontal and parietal areas, but experts also make use of the medial temporal regions.

Support for the skilled memory research is found in studies of the development of digit-span skill (Chase & Ericsson, 1982), observations of a skilled waiter (Ericsson & Polson, 1988), and investigations of mental calculators.

2.1.2 Ericsson's Theory of Deliberate Practice

Eysenck and Keane (2020, p. 612-613; 621) maintain that, according to Ericsson (1988) the development of expertise depends only on deliberate practice (DP), a highly structured activity, with the explicit goal to improve performances. Thus, two questions arise: a) What determines the effectiveness of extensive practice (Ericsson, 2017), and b) What factors other than focused practice are required to become a chess expert?

Ericsson (1988; 2017) argues that not only are various requirements and components necessary for a chess player to develop the problem-solving and memory skills essential for chess but they must also be applicable to problem solving in educational settings (Eysenck, & Keane, 2020; Gobet, 2016; McDevitt, & Ormrod, 2013). A few components of DP include motivation and a will to improve; constant focus, especially when breaking a task into more manageable small parts; and immediate verbal feedback and knowledge of the results of one's performance must be given (Hagan, Smith, & Gettman, 1981).

Edward Thorndike developed three laws of learning and future training: The Law of readiness, referring to when an individual is ready to learn based on past experiences and reinforcements (Thorndike & Woodworth, 1901). The Law of exercise refers to behaviour that becomes stronger when enforced and lastly, the Law of effect, referring to behaviour that when receiving positive feedback or is rewarded, would most likely be repeated in future. These laws are based on practice and drills to learn something over a long period (Cherry, 2023). Hence, repeated practice strengthens the connections between neurons in the brain, which make it easier for the behaviour to occur again.

According to Ericsson and Lehman's (1996) general theory of expertise, a wide range of expertise can be developed when a chess player is actively involved in the learning process and the four aspects of DP, all of which are conducive to learning, are:

- The chess instruction to children and their chess practice must be set at an appropriate or required level of difficulty such that it is not too difficult or too easy for them; if some children, for example have developmental problems, it must be reckoned with;
- The learner is provided with informative (verbal) feedback and guidance about his or her performance or chess playing on the chess board; and
- The learners must have ample opportunities and time for repetition in chess practice, and chances to correct his or her errors/mistakes. One should bear in mind the amount of time required for chess practice or the process of upskilling depends on the different goals of chess players, for example, research indicates that approximately 25 hours of chess practice is needed to obtain a significant chess effect in research studies (Sala & Gobet, 2017; 2020).

Some researchers believe that when a child has developmental problems, enough time is needed for practice, for example Storey (2000) and Ogneva (2017), and other researchers maintain that when an expert chess player wants to become a grandmaster, much more time is needed (Chase & Simon, 1973).

- Thus, when exposing learners to chess practice, it must be tailored to the individual needs of the learners or chess players. It must be carried out in depth from simple to complex in a spiral manner and information must be assembled in a meaningful manner by relating it to pre-existing knowledge (Gobet, 2016; 2017).

Hence, the performance level of chess players is related to the amount of goal-directed structured practice, which is repetitive, requires effort and motivation, and is not enjoyable. Moreover, more intelligent players are probably the ones who will persevere with chess practice (Eysenck & Keane, 2020, p. 613; Gobet, 2016). Thus, DP acquires the learner to use three crucial skill-building strategies during practices, namely focused practices, spaced practices, and feedback focus practices. Moreover, DP training activities can include different training activities by oneself or in groups, for example, individual self-study or chess practice on a chess application, or in the company of a coach, or in chess playing groups, that is, group practice. Deliberate practice also includes exposure to various problems in chess classes or by competing, and on a chess application.

According to the Power Law of Practice, an example of the learning curve effect on performance in chess as a function of time, the performance of an expert is a monotonic function of the amount of deliberate practice. The more a player practices specific skills, the more quickly and accurately this player can improve these skills, and the higher the chances are to perform them in future (Ericsson, 1988; Roessingh & Hilburn, 1999).

Ericsson and Lehman (1996) explain that it is not just the accumulation of chess practice, but rather the amount of DP in terms of time, for example, approximately ten years or from 10 000 to 50 000 hours, that causes an improvement of chess skill (see also Gladwell, 2013). However, players at different skill levels need different amounts of DP; therefore, practice alone is not sufficient to achieve competency or excellency in the chess domain. It should also be noted that performance level can influence the amount of practice in a positive way. Moreover, Campitelli and Gobet (2008; 2010) postulate that there is a correlation in chess expertise between total practice hours and chess skill. These researchers identified three predictions from DP theory but these three predictions have not been fully supported by evidence based on actual chess players; for example, chess players who devoted more than 20,000 hours of chess practice did not become chess masters. Furthermore, Magnus Carlsen disproves the main assumptions of Ericsson's DP theory because he became a grandmaster after five years of focused practice and DP. Consequently, Carlsen did not accumulate more years of DP than other top chess players (Eysenck & Keane, 2020).

2.1.2.1 Criticism. The DP theory of Ericsson and goal setting is the primary mechanism to create behaviour changes such as improvements in chess competence and excellence as well as in cognitive and intellectual abilities and brain regions of expert chess players; thus, DP and goal setting is necessary but not sufficient (Charness, Krampe, Reingold, Tuffiash, Reingold**,** & Vasyukova, 2005; Jones, 1990). However, there is criticism has been levelled at this important chess improvement theory, because it does not provide adequate recognition of individual differences and inborn talent or abilities; thus, the DP theory is too narrow in scope according to various researchers (Burgoyne, Charness, Hambrick, Macnamara, & Nye, 2019; Gobet, 2016, Macnamara, Hambrick, & Oswald, 2014). There is also an inaccurate estimation of time needed to accumulate chess playing or DP, or the number of games needed to be played (Howard, 2009;

Sternberg & Sternberg, 2012, p. 613). In addition, no recognition was given to a performance ceiling effect of the number of games (approximately 750) when aiming to acquire chess expertise or to improve competency; and not enough recognition was accorded to (high) levels of variability amongst individual chess players. Further, the description of training activities in the structured framework of deliberate practice is too vague. In the light of the mentioned reasons, there are some limitations to this theory and it needs more proper research (Burgoyne et al., 2019). The main issues are that all chess players engaging in DP do not reach chess excellence or achieve high skill levels, and the implication of the theory is that all the individual skill levels should benefit comparably from any given amount of distributed practice, but this is not the case.

2.1.2.2 In sum. It appears that if the beneficial effects of DP are limited because Howard (2009) found clear performance differences early in a group of chess players, which increased up to approximately 750 games. Furthermore, the findings suggest that detection of chess expertise is already possible early in the careers of chess players, because it is then possible to identify those who will eventually attain chess expertise and become outstanding chess players, possibly due to the fact that they have very high natural talent. Macnamara et al. (2014) explain that Ericsson's research is oversimplified and it provides an extreme environmental focus to understanding the development of chess expertise, to mention just some of the criticism against DP (Baddeley, 1995; Ullén, Hambrick & Mosing, 2016). Lastly, Gobet (2016) explains that while deliberate practice is important in reaching superior performance, the framework suffers from serious weaknesses because it ignores the presence of other practice activities and the role of motivation by trainers on players. Furthermore, regardless of clear successes being recommended by the DP framework, early specialisation in sports has attracted much criticism due to the occurrence of burnout in sports and the high dropout count in the chess domain (Gobet, 2016; Dewang, 2023).

Most of the techniques offered to explain the effects of practice and the acquisition of expertise have developed in the context of the architecture models of cognition, which are discussed in the next section.

2.1.3 Anderson's Adaptive Control of Thought-Rational Theory (ACT-R)

Some of the most popular architectures for cognitive modelling include ACT-R Clarion, LIDA, and Soar. According to this theory, the aim of the cognitive system is to optimise the adaptation of the behaviour of the organism (Eysenck & Keane, 2020, pp. 29-32). Furthermore, the ACT-R attempts to provide a theoretical framework for understanding processing and performance of numerous cognitive tasks. Thus, this model of cognition of Anderson (1990; 1996) comprises a set of programmable information processing mechanisms that can be used to predict and explain human behaviour, including cognition and interaction with the environment.

The three interconnected systems (or stages) in this theory, are declarative memory (learnt quickly), procedural or production memory (takes quite a substantial amount of [chess] practice to learn and accumulate skills), and working memory (Eysenck & Keane, 2020). The latter store contains information that is currently active and coupled with attention and templates in the long-term memory store. The assumption of ACT-R theory is that skill acquisition involves knowledge compilation, with a progressive shift from the use of theoretical knowledge in, for example chess playing, to the use of physical chess practice in procedural knowledge (Anderson, 1996; Eysenck & Keane 2020, pp 29-33). According to Anderson (1990), it is often not possible to gain conscious access to procedural knowledge but whenever a production rule matches the current contents of working memory, automatisms can follow. However, Eysenck and Keane (2020, pp. 30–34; 600–604) and Anderson differ from one another regarding a real difference between the conscious levels of automated actions (or automatisms) or skills.

Nonetheless, the skilled performance of chess experts seems to depend more on procedural knowledge than on declarative knowledge according to the ACT-R theory, although it should be noted that these systems are interdependent (Eysenck, & Keane, 2020; Whitehead, 1929). Furthermore, ACT-R assumes that the cognitive system consists of several independent cognitive modules (or subsystems) with buffers. For example, one of these modules can control a player's hands when moving chess pieces on the board. Some types of these modules are related to retrieval, imagery, goal-achievement, and procedural aspects. In addition, the theory combines complex cognitive science with cognitive neuroscience by identifying the brain regions associated with each module (Eysenck & Keane, 2020, pp. 30-31). Hence, a central production system can detect patterns in these buffers and take coordinated action.

In cognitive neuroscience, ACT-R models have been successfully used to predict prefrontal and parietal activity in memory retrieval, anterior cingulate activity for control operations and practice-related changes in brain activity, according to Stocco, Lebiere, Morrison, Rice, Smith, and Thomson (2023).

2.1.3.1 Criticism. In practice, it is very difficult to test such a theory due to its broad nature (Eysenck & Keane, 2020, pp. 30-31). Furthermore, areas of prefrontal cortex generally assumed to be of major importance in cognition are de-emphasised owing to the existence of several modules. In fact, research within cognitive neuroscience increasingly reveals the importance of cognitive processing in networks of the brain rather than in specific regions. Lieto, Lebiere, and Oltramari (2018) points out that in comparison with most other cognitive architectures, ACT-R has a knowledge base that is much smaller than that possessed by humans; therefore, the applicability of ACT-R to human cognitive performance is even more reduced. Moreover, in ACT theory, there is an occurrence of occasional transfer of production rules, acquired in one context transferred to another context or situation, which confirms that transfer does occur. However, the notion of transfer stands in contrast to what the ACT-R theory proposes (Eysenck & Keane, 2020; Koedinger & Anderson, 1990;).

Researchers argue that this approach is, in general, most applicable to the development of routine expertise, which is very important in education, and it is less appropriate with reference to expertise that is adaptive. Nonetheless, according to Gobet (2016, p. 156), ACT-R is based on a detailed theory of production acquisition and has led to intelligent mentoring systems that have been successful and widely used in schools abroad. However, Gobet (2016) suggested that a more multidisciplinary approach is needed; therefore, beyond DP and the older production models, the multifactorial gene-environment interaction model is offered by Ullén et al. (2016; Eysenck & Keane, 2020, pp. 617 – 621) and discussed in the next section.

2.1.4 The Multifactorial Gene-Environment Interaction Model (MGIM)

Hambrick et al. (2019, p. 291) and Burgoyne et al. (2019) explain that, at the core of the MGIM model, is the assumption that expertise is determined by multiple factors (Persky & Robinson, 2017).

The main assumptions of the multifactorial model, is the following:

The development of expertise depends on both domain-specific knowledge and skills, fostered by focused practice, and domain-general abilities, such as cognitive ability and personality;

Recognition is being given to interaction between genes and the environment where the magnitude of genetic influences on performance varies as a function of the nature of environmental experiences, thus both influences one another. According to this MGIM model, DP increases expertise to some extent due to the influence on neural mechanisms, for example, brain plasticity.

Lastly, individual differences in structured deliberate practice are determined in part by genetic factors relating to personality, abilities, and motivation.

2.1.4.1 Findings. Hambrick et al. (2019) maintain that expertise in many areas such as chess depends on the domain-general ability and intelligence, and that there is evidence supporting this assumption. Thus, Burgoyne et al. (2019) posit that intelligence is positively correlated with chess expertise.

There is evidence for the interaction and correlation in gene-environment assumptions, although it is more applicable to music practice in twins than in the chess domain; however, researchers maintain that innate talent or intelligence (*g*-matter) is also relevant (Hambrick & Tucker-Drob, 2015). Moreover, pertaining to the DP assumption deliberate practice increases expertise partly by modifying the neural mechanism. It has been supported by the evidence (De Manzano & Ullén, 2018) despite problems with establishing that DP exerts causal influences on neural mechanisms.

According to the evidence of Ullén et al. (2016), personality plays a role in determining individual differences in DP. They explain that high levels of conscientiousness are associated with high levels of deliberate practice, whereas high levels of impulsivity are associated with chess players who were engaged in a lower amount of focused practice. There is neuroscientific evidence of benefits of chess playing in the frontal lobe due to the absence [and control] of impulsivity in people with brain damage. Moreover, there is also evidence that motivation and goalsetting affects the amount of deliberate practice. For example, Ackerman (2014) maintains that vocational interests of individuals influence what they choose to focus on and how much time and effort they want to spend on their interests.

2.1.4.2 Evaluation. The MGIM includes more variables and factors in the model; hence, it appears to be more ambitious in scope than the Ericsson DP approach. There is sufficient support for most of the factors identified by the model and that influence the development of expertise. There is also evidence that these factors interact in complex ways that are largely consistent with the predictions of the gene-environment-interaction model, but a 'chess gene' has not yet been isolated. Intelligence, in part can have a genetic base (called '*g'* matter), notwithstanding that the environments in which a person lives are also recognised as contributory factors, by this theory (also see Bocchi et al. 2024).

Criticism: This model is currently the most comprehensive model humans have of the development of expertise; however, more research is needed to test some of the complex predictions made by the model. It is relevant to note that the model predicts that interactions among the factors influencing the development of expertise will vary over time. Thus, further knowledge is needed to assess why or how much interactions will influence the development of expertise over time and there is also a need for more longitudinal studies to test such predictions.

In the next section, the Practice-Plasticity-(cognitive) Processes model (PPP), an integrative approach to looking into cognitive processes and the development of chess genii, are briefly presented (Campitelli et al. 2014).

2.1.5 The Practice-Plasticity-(Cognitive) Processes Model (PPP)

Reasons why the chess environment is an ideal environment for studying chess excellence, are not only due to the existence of scales measuring chess ability, namely Elo ratings (1978), but what is universally said of other expressions of cognitive skill. According to the 2024 FIDE (International Chess Federation, 2024), these interval scales in the ratings of chess players indicate the various playing strengths of the experts, which are important when preparing for chess competitions against one another. A variety of longitudinal data that contains certain important information, for example, about the 'starting age' for professional chess playing or 'handedness' of players, their performances, and their cognitive abilities, are then available. The 2024 FIDE provides easy access to chess players (also see Elo, 1978).

In this PPP model, other earlier models and theories are also important, namely the Elementary Perceiver and Memorizer (EPAM), a computer model of rote learning advanced by Simon and Newell (1970); the Chunk Hierarchy and REtrieval STructures (CHREST), an architecture model motivated by Gobet and Jansen (1994); the template theory of Gobet and Simon (1996; Chase & Ericsson, 1982); Gobet, (2016) implemented in CHREST (Gobet & Lane, 2010); and the SEARCH model of Gobet (1997). However, the focus now falls on the Practice-Plasticity-Processes model (see Section 2.1).

Intelligence or innate abilities play an important role in chess excellence, according to Ericsson (1988), and in this Practice-Plasticity-(cognitive) Processes model (Campitelli et al., 2014). Furthermore, neural plasticity and cognitive processes, namely domain specific pattern recognition and heuristics, are important explanatory variables in this model. In fact, neural plasticity is the greatest in children even though the anatomical circuits consolidate from age eleven to twelve. Thus, there are differences in brain structure between experts and novices (e.g., taxi drivers). Training studies, especially in music, have shown that these changes in brain structure are often caused by expertise and reflect brain plasticity (Eysenck & Keane, 2020, p. 620). Consequently, the structural changes associated with brain plasticity provide experts with an additional benefit compared with non-experts. However, researchers postulate that older chess players peak at age 35 but that there is a decline in chess skill in older chess players at age 65 when brain plasticity declines; hence, a critical period exists in the chess domain (Campitelli et al*.* 2014). Researchers posit that not only is there a relationship between intelligence and chess skill (Grabner, Ansari, & De Smedt, 2012) in adults, but also between intelligence and chess skill in children (Frydman & Lynn, 1992). The relationship between intelligence and chess skill in children is stronger.

Some researchers suggest that there is a correlation between the starting age of chess playing and the age of the first achievement (Campitelli et al., 2014). During the last two decades, remarkable achievements in young chess players have been noted, for example, Magnus Carlsen, Edit Polgar, and Abhimanyu Mishra, to name a few child prodigies (Campitelli et al., 2014). These researchers tried to offer explanations for Carlsen's early success in chess playing in as much as he could have erred when reporting all the hours of accumulated chess practice in a subjective self-report (Simon & Chase, 1973). In 1999, Howard investigated a possible rise in human intelligence worldwide, which also did not reveal significant results (Howard, 2009). Hence, according to this model, there is a strong correlation between accumulating the number of hours of practice and chess skill. However, the number of chess games played is considered to be a stronger indicator of chess excellence (approximately 750) than merely accumulating hours of chess practice.

Campitelli et al. (2014) hold that the improvement in chess excellence could be due to the increase of the professionalism of chess playing on various levels the chess domain during the last decades. It is possible that the leadership and governance of the Federation Internationale des Echecs (FIDE) as well as the data capturing and statistics have improved tremendously, because many changes have occurred in chess, for example blitz competitions, and time controls. Lastly, there is also better support and guidance for professional chess players with more exposure to competitions (also see Dewang 2023; Elo, 1978).

In the next section, the theories of human development are discussed.

2.2 Theories of Human Development

Developmental psychology is the study of how people grow and change throughout their lives. Many developmental psychologists focus on the physical, intellectual, mentally, social, and emotional development of infants, children, and adolescents, over time (Dorwart, 2023). The aim of developmental researchers is to expose the mechanisms that drive complex cognitive development processes in young children and to explain the contribution of genetic and environmental factors to this general process (Eysenck & Keane, 2020).

It is noteworthy that cognition, according to the information processing theory, is at the centre of intelligence (Sternberg & Sternberg, 2012). Numerous controlled or manipulated factors influence human cognitive processing and performance (Eysenck & Keane 2020). Cognitive researchers describe four main approaches to human cognition which will form the backdrop of this chapter. The four approaches are a) cognitive psychology which involves the use of behavioural evidence to enhance an understanding of human cognition; b) cognitive neuropsychology involves studying patients with brain-damage; c) cognitive neuroscience involves using evidence from behaviour and the brain to understand cognition; and d) computational cognitive science that involves developing computational models to further one's understanding of human cognition, where such models incorporate knowledge of behaviour and the brain. In fact, these computational models are designed to simulate human processing of a given task (Eysenck & Keane, 2005, pp. 2-39; 35-37). These approaches can be used on their own or combined with another approach, depending on the purpose of the study. Lastly, behavioural data are not only of great importance within cognitive psychology but also within cognitive neuroscience and cognitive neuropsychology. Hence, the influence of cognitive psychology is significant, and the focus will therefore mostly fall on cognitive psychology in the subsequent discussion in this chapter (e.g., see "strengths and limitations of major approaches to human cognition"; Eysenck & Keane, 2020, p.35).

The developmental theory of (four) fairly-fixed developmental stages as advanced by Piaget is regarded as an important theory of cognitive development by researchers worldwide and it will be considered first in the ensuing discussion (Piaget, 1980/1952; Sternberg & Sternberg, 2012). This discussion is followed by the popular information processing paradigm in cognition, which is relevant to modern cognitive psychology and also to research in chess. This paradigm in psychology and learning, focuses on cognitive or neural mechanisms or processes and cognitive building blocks, which are used as a background when comparing novice chess players with chess experts (Sheridan & Reingold, 2014; Wright, Gobet, Chassy, & Ramchandani, 2013).

Developmental researchers would also like to know how expert chess players tackle similar problems to those that non-expert and less skilled players do, and what changes take place in cognitive processes or in different brain regions of more skilled chess players after structured and focused chess practice (Bilalić, Gobet, & McLeod, 2007; 2008; Charness, 1991; Gobet et al. 2004). The difference between skilled and novice chess players is a central topic that will be dealt with in some detail in this current research study.

The major theories of human development are Arnold Gesell's maturation theory (Gesell, 1940); the constructivist, cognitive developmental theory of Jean Piaget (1980/1952); the psychosocial stage theory of Erik Erikson (1972); the ecological systems theory of Urie Bronfenbrenner (1979; 1989); and the sociocultural theory of Lev Vygotsky (1997), which is also relevant in this investigation because it is both a social and cognitive development theory. It should however be noted that developmental psychology is an extremely large area of research, and therefore, only some aspects will be considered in this current research study.

The following overview is mainly intended to pave the way for an examination of a possible relationship between chess and cognition as represented by mean scores of the measuring instruments for young children, namely the Junior South African Intelligence Scales and the Aptitude Tests for School Beginners. Researchers generally agree that the brains of young children are still malleable and plastic until the age of about eleven to twelve years, and that it is mainly due to this neuroplasticity that they demonstrate an exceptional ability to learn during this period (Gobet, 2012; 2016; Gobet & Campitelli, 2006).

2.2.1 A Biological base for learning in Developmental Psychology. Learning firstly is a consequence of many physical changes that take place in the brain, due to neuroplasticity and maturation, so that children can progress from a state of relative incomprehension to a state of complex cognition involving language, memory, and reasoning abilities (Eysenck & Keane, 2020; Spratling, 2017; Spratling & Johnson, 2006). Thus, various neural macro-level organisational developments and structural changes occur during this process. Consequently, certain researchers believe that the magnitude and scope of these neural networks and their performance are quite powerful as a whole (Bruer, 1999; Wang, Liu, & Wang, 2003). For instance, the fontanelle of a newborn must close at approximately six months while the head grows tremendously in size, and certain impulses or reactions must disappear in cognitive processes. Furthermore, associative networks develop and connect different brain systems and the firing of signals or messages between synapses need to develop when exposed to new learning matter (McDevitt & Ormrod, 2013). If no new material or learning is provided, some of the multiple neurons of a child may even disappear.

Yet, even if the initial developmental period is mainly steered by genetic factors, there is substantial evidence that environmental factors also affect and facilitate learning processes in young children. Thus, some researchers posit that young children benefit from additional stimulation when they are exposed to enriching programmes and stimulating environments (Grieve, 2005; Howe, Davidson, & Sloboda, 1998). Although most of the researchers agree that intellectual skills can be enhanced, they disagree with regards to the degree to which such improvements can be achieved and the means by which this occurs. Nevertheless, most researchers would concur with the notion that there is a complex interaction between genetic and environmental influences, although the exact nature of this interaction is still not known.

In 2019, a link between poverty and an insufficient quality of school readiness was confirmed due to various factors in a longitudinal study conducted by the American Academy of Pediatrics (AAP) over eight years. The study revealed that poverty can change the architecture of the brains of young children (Britto, 2012; Spaull, 2013). The AAP study and Grigorenko (2000) suggested that while the genetic inheritance in children (due to nature) may raise an upper limit of cognitive and intellectual development, their individual cognitive abilities and intelligence can still be inflated, perhaps within a limited range, by exposing them to supplementary stimulation. Before discussing such stimulation in greater detail in addition to the role that chess instruction could play in assisting the process, brief consideration is afforded to the stage theory of cognitive development, as advanced by Jean Piaget and his co-founder, Bą̈rbel Inhelder (Inhelder & Piaget, 1958).

2.2.2 Piaget's Cognitive Developmental Theory

To gain a deeper understanding of young children while the children were acting as mini scientists when they explored their worlds/environments, Piaget and Inhelder observed children during these studies. Their theory can be viewed as a constructivist epigenetic theory of development, and it is still very influential in psychology in South Africa and in other countries, according to Prof. Luneta (Luneta & Giannakopoulus, 2016). Thus, the theoretical framework and research findings of these researchers continue to stimulate research in developmental psychology (e.g., Piaget, 1980/1952). In this theory, young preschool children are regarded to be neurologically immature, and consequently early developmental processes could depend on maturational factors and not only on the accumulation of knowledge (Gesell, 1940).

Furthermore, the theory emphasises the role that neurobiological structures play in the development of cognition, and also posits that cognitive development in children entails that they need to build or develop a mental model of the world that they live in. Piaget maintains that children's intelligence undergoes changes as they grow, and that the ability to use and represent symbols must be assembled by experience and practice before complex patterns of thinking and reasoning can occur (Ormrod, 2006, pp. 24-31**).**

2.2.2.1 Four Stages of Intellectual Development. Based on Piaget's observation of his own children, he put forth the idea of four distinct developmental stages through which children learn a language, learn to memorise, and learn to reason. The stages are: a) The sensorimotor stage (from birth to 24 months); b) the pre-operational thinking stage in toddlerhood (from 18-24 months to age 7); c) the concrete operational stage (ages 7 to 11); d) the formal operational stage (adolescence through adulthood); and some researchers posit e) a post formal stage that may involve a tendency towards dialectical thinking (Inhelder & Piaget, 1958). The Grade R learner-participants in Stage 1 and Stage 2 of this thesis reside in the pre-operational (toddlerhood) stage (24 months to age 7). According to Piagetian theory, the stages outline a sequence of increasingly complex ways of thinking, and a number of gradual steps and shifts occur that children pass through on their path to an understanding of the world. One advantage of Piaget's theory is that it can be practically applied. Thus, teachers as well as chess trainers can apply Piaget's notions (broad categories) of assimilation and accommodation in the classroom and in chess tutoring when they introduce new learning material. The teachers can help the Grade R learners to approach a new idea through the lens of what they have already learned in the past that is, prior knowledge. By accommodating this new experience and adapting their knowledge of the way the world works, they construct a more reliable mental conception or model of the world.

In the formal operational stage, adolescents become capable of formal operational thought and they can apply logical reasoning processes to abstract ideas and concrete objects. Campitelli and Gobet (2008), therefore, argue that this is probably why chess players in general begin to play competitively at this age. Other abilities that are important for advanced scientific and mathematical reasoning also develop at this stage which coincides with the period when plasticity in children reduces as an effect of the merging of anatomical circuits.

Piaget's cognitive theory gives a clear framework for the ways in which children at different ages and stages are capable of learning. Consequently, knowing and understanding the predictions of his theoretical model, could help and empower teachers when they guide a child to discover the world in terms of their own teaching approaches. Piaget's theory stresses the need for prioritising learning through experience instead of just memorising (rote learning) the information, which is supported by Whitehead (1929).

When young children are exposed to new experiences, such as chess playing, challenges must be matched to learners' individual abilities (Ericsson, 1988; Ogneva, 2017; Storey, 2000).

2.2.2.1.1 Criticism. The work of Piaget enjoys much support but Rogoff (2003) suggests that Piaget's theory could rather be viewed as a theory of how children can think about their worlds as the nature of cognitive development may be somewhat specific to different conditions, cultures, and content areas (also see Grieve, 2005; Ormrod, 2006, p. 31). Piaget's cognitive theory, neglects the social nature of human development, according to the following researchers, Matusov & Hayes

(2000) and Vygotsky (1997); hence, researchers such as Bronfenbrenner (1979; 1989) and Vygotsky (1997) place a greater emphasis on social factors due to a link between the input and information acquired via social interaction, with the result that Bronfenbrenner defined these as bi-directional influences. Likewise, researchers elaborate on this link by maintaining that external instruction in the form of structured instruction and modelling must initially be provided by adults (e.g., parents or caretakers, teachers, instructors, and coaches) to children during the early stages to enhance cooperative learning and to facilitate structural interdependence, and that this allows children to perform on a higher level (De Groot, 1978; Ormrod, 2006, pp. 465-467). These researchers contend that, over time, less support (in a spiral manner) will be provided to children, gradually forcing them to accept more and more responsibility for their own learning (also see Gobet, 2016).

Researchers (McDevitt & Ormrod, 2013; Vygotsky, 1997) explain that in this manner children begin to guide their own learning and metacognitive processes.

2.2.2.2 From Stages to Information Processing. Piaget's theory is based on the main idea that children's understanding and perception of the world appear in discrete and genetically determined developmental stages but some researchers do not regard children's developmental stages as discrete or discontinuous (Willingham, 2008). They contend that the development of children appears to be a more continuous process and that there is considerable fluctuation in task performance among children. Thus, Willingham (2008) postulates that not only will different children in the same age group perform different tasks differently, but the same children may even perform similar tasks differently on consecutive days. Nevertheless, there is some support for stage-like changes in development when neural networks are examined, even though the underlying neural learning mechanism may be continuous (Ouinlan, Booij, Jansen, Rendell, & Van der Maas, 2007). Moreover, Meyer (2009) maintains that Piaget's theory conceptualises cognitive growth as a constructivist process in terms of which meaning and understanding unfolds, based on the process of knowledge acquisition through experience, and not just under the control of innate knowledge and abilities. Piaget maintains that children construct their knowledge and cognitive abilities by self-reflective action in the world in agreement with the processes of accommodation and assimilation. Thus, the constructivist paradigm is founded on the postulate that children construct their knowledge adaptively by actions in the world and that they continuously adapt their knowledge and mental representation of the world based on their own experiences (Inhelder & Piaget, 1958).

2.2.4.1 Cognitive Mechanisms. It is within this broad theoretical landscape of exploring cognitive mechanisms emerging from the work of Inhelder and Piaget that much of the current research in cognitive development can be situated. However, Piaget regards empirical issues to be important. He describes cognitive development in terms of broad categories or two general processes underlying cognitive growth but did not explore or investigate the cognitive mechanisms underlying these processes in testable models of cognition. Moreover, Piaget did not formulate a model of how particular cognitive processes such as perception or memory emerge in young children. Developmental researchers such as Robbie Case (1985; 1992) have extended the theory of Piaget in several broad directions, for example, neo-constructivism and neo-Piagetian research. Neo-Piagetian researchers developed the notion of executive control stages as building blocks of different developmental stages and how the stages unfold/occur. Case (1985; 1992) emphasised the importance of individual differences in intelligence which plays an important role in complex domains such as physics, music, mathematics, or chess playing.

2.2.4.2 Cognitive Mechanisms in the Information Processing Paradigm. Much of the research on developmental processes has been conducted within the information processing paradigm, which is an attendant computational metaphor or a dominant intellectual tool for conceptualising the brain and mind, based on the program or computer metaphor underlying some theories of cognition (Biron, 1993; Bouchrika, 2024). Robinson-Riegler and Robinson-Riegler (2004, pp. 26-29) point out that the guiding idea underlying this paradigm is that information flows through a limited capacity system of mental "hardware" (the brain) and "software" (the mind). The framework is based on the concept of human computation, metaphorically borrowed from digital computers. Hence, in this paradigm, a functionalist and algorithmic description is provided to capture various mental processes.

The information processing account has been extensively applied in research and the development of theory of various cognitive processes such as perception, memory, and learning. Fodor (1975; 1980) maintains that each of these cognitive processes constitutes an independent module and that these cognitive processes can be explained as mental rules and operations applied to internal cognitive representations. This framework of rules and representations underlies much of the early work in cognitive psychology and linguistics (Robinson-Riegler & Robinson-Riegler, 2004, p. 26).

The information processing paradigm implies a theory of learning. In effect, it posits that learning becomes easier and more efficient as the cognitive processes and procedures associated with the processing of concepts, tasks, and problems in a domain become more fluent and achieve automaticity (Eysenck & Keane, 2020). The acquisition of expertise in certain domains, is based on extensive repeated practice, which facilitates the execution of cognitive processes in developmental fields (Ericsson, 1988). According to Sternberg and Sternberg (2012), information processing in cognition can be viewed in terms of three different kinds of highly interdependent components.

First, the meta-components refer to higher-order executive processes used to plan, monitor, and evaluate problem solving; then second, the performance components entail a lower-order processes, used for implementing the commands of the meta-components, namely executive processes; and third, the knowledge-acquisition components, pertaining to the processes used for learning (how) to solve problems in the first place. For example, when asked to write a term paper, the learner would make use of meta-components for higher-order decisions. Moreover, the learner would decide on a topic, plan the paper, carry out research about the topic, monitor the writing, and evaluate how well the finished product succeeds in accomplishing the goals set for the paper. The learner would also use knowledge-acquisition components to learn about the performance components for the actual writing thereof.

The popular information processing system and the cognitive mechanisms in this system have been discussed. The cognitive complexity of chess will be considered in the next section.

2.3 The Cognitive Complexity of Chess

It is noteworthy that chess and Go are both regarded as complicated boardgames, and have evoked considerable interest in cognitive psychology. Go is considered to be even more complicated than the chess game because it occupies a larger 19×19 board (with 361 positions, and a state space of 170) than the (64 square) chess board (Robson, 1983).

There are various reasons why chess is viewed as a cognitively complex game in cognitive science and psychology (Tromp & Farneback,2007). The cognitive field surrounding chess expertise is complex and chess playing has been researched by numerous researchers all over the world throughout ages (see also Charness 1991; 1992). The combinatorial game theory (Sjöstrand**,** 2015) which deals exclusively with two-player games with the 'perfect information and no chance moves, and with a win-or-lose outcome', measured game complexity in many well-known games such as chess playing (Ferguson & Allen, 1998). For example, there are 64 positions on a chess board; the state space complexity is 44; the games-tree complexity is 123; the average game length branching factor is 70; a complexity class of a suitable generalised game is EXPTIME-complete (without the 50-move drawing rule) and chess requires exponential time (also see Fraenkel & Lichtenstein, 1981; Shannon, 1950; Shor, 1994). Furthermore, the chess game has sixteen chess pieces per player, they move and operate in different directions and ways, and they are weighted differently. With every move a player makes, possible or real, losses of chess pieces and their weights must be compared with one another.

Moreover, there is a symbolic representation coding system or notation which all players who compete in competitions at schools or clubs or in group practice must adhere to from a young age. In notation, players record all the moves that the two chess players make during a match according to the outlay of the chess board in a prescribed manner. This probably initially enhances visuospatial skills. Chess is a visuospatial game, but due to the complexity of the game, only a few expert chess players are capable of performing the required visualisation processes in blind-folded chess games or simultaneous blind-fold matches to produce games of a high quality in competitive play against other players (Frydman & Lynn, 1992; Waters et al., 2002). It should also be noted that the top chess players are often creative in their chess playing and they make of use of intuition and not just calculations (Gobet, 2011; Gobet & Ereku, 2014; Kasparov, 2017).

Thus, while it may be easy for most children to learn the basic rules of the game, it takes time for them to master all the intricacies of the opening and end play strategies (Sigirtmac, 2012; Stephan, 2011; Wetz, 2004). There are many thousands of different openings lines and opening variants that players can use in chess playing. Also, only a few players manage to achieve the standard play required for international master or grandmaster levels, and most players do not reach this level despite the fact that they have accumulated the required amount or number of chess games suggested by the deliberate practice theory (Copeland & Turing, 1999; Simon & Chase, 1973). Some players even suffer from mental fatigue when competing, especially after being exposed to long games, for example, up to four hours, and even more so if they were restricted in physical movement (also see Kottke, 2019; Gobet, 2016).

Perspective taking or theory of mind is crucial in chess playing because a chess player must guess (or reason) what the next move or moves of the opponent will be and the reasons for it based on what the consequences for the opponent could be when they move the chess pieces in a certain way or engage in a gambit or possible sacrifice of a chess pieces. In other words, each chess player plays for two people when competing, and it can be very exhausting for certain chess players, probably more tiring for non-skilled chess players than for experts who are very skilled problem-solvers (Gao, Lin, Wang, & Wei, 2019; Malamed, 2009; Kottke, 2019). It is also relevant to take into consideration the additional cognitive demands in thinking that amateurs have to deal with due to a limited working memory capacity and because what seems to be easy for experts or highly skilled players, could be difficult for novice chess players (Persky & Robinson, 2017).

There are an extraordinary number of different possible moves in a chess game. Claude Shannon (1950) tried to estimate the actual number and came up with 10^{40} if illegal moves are discounted. There are also many millions of different high-level chess games that have been recorded in very large chess databases such as the mega database of ChessBase (ChessBase, 2024). Charness (1991; 1992) posits that there are approximately 50 000 opening variations in chess and each of these could lead to millions of different middle games and end games. As Gobet and his colleagues explain, in a chess game, there are “arguably more possibilities than atoms in the universe” (Gobet et al., 2011, p. 225).

Furthermore, the complexity of chess has been demonstrated in computational and mathematical analyses and, according to Garey and Johnson (1979), one way to quantify the complexity of games is with the help of the theory of computational complexity (Eysenck & Keane, 2020). This theory analyses problems in terms of their inherent difficulty based on the assumption that an indication of the level of difficulty associated with problems is given by the available resources (i.e., memory) and time, which is measured as the number of computations required to solve them on an abstract machine. Moreover, a distinction is drawn between the set of decision problems solvable by a deterministic Turing machine in $O(^{2p(n)})$ time, and those that require exponential time and good memorising resources, and that cannot be solved by such a machine in polynomial time. Garey and Johnson (1979) describe this very difficult set of problems as NP-complete problems, where NP stands for non-polynomial.

So far, there is no known mathematical method or computer algorithm capable of finding correct solutions to these NP-complete problems in a practical amount of time, and many mathematicians doubt that such algorithms do exist (Papadimitriou, 1994). Nonetheless, Copeland and Proudfoot (1999) believe that, in future, it may be possible to find an approximation to the correct solution by making use of heuristics; for example, using a guessing machine such as the super-Turing machines described in the theory of hypercomputation.

A chess player wins a chess game, when he or she manages to calculate a method of winning the game, which in turn, means finding a sequence of moves that will checkmate the opponent, starting from any opening move that the opponent makes. One should bear in mind that chess players can also loose a match when they have run out of time, as allowed in classical matches or due to making illegal moves.

Shannon (1950) and Storer (1983) investigated solving chess, and an existence of a winning strategy for one of the two chess players by performing different mathematical analyses but it seems that there is some consensus of the complexity of chess that it is not practically possible to compute a sequence of moves that is guaranteed to win the game of chess. The computational complexity of chess stems from the fact that even though it is a deterministic, perfect combinatorial game, there is a classic combinatorial explosion of possible moves in any reasonable chess game (i.e., a game that is not concluded by a checkmate within the first 10 moves of a game) (Fraenkel & Lichtenstein, 1981).

Furthermore, chess is not solvable by simple brute form strategies on even the most powerful supercomputers currently available but it is possible that, in future, chess may be solvable on quantum, probabilistic, or non-deterministic computers.

In the light of the excessive move complexity of the chess game, players gain knowledge about openings of chess strategies and devote a vast amount of time studying games of classical and modern chess players, for example, Capablanca, Fischer, Kasparov and Carlsen (Eysenck & Keane, 2020, p. 613-614). To learn to play chess at an expert level requires considerable time, structure and focus, devotion to the game, motivation for practice and openness to come up with creative problem solving because not even natural inborn talent is sufficient to guarantee success in the game; it requires hard, effortful work. Thus, Simon and Chase (1973) postulate that up to 3 000 hours are needed to become a chess expert and more than 30 000 hours to become a chess master (also see Ericsson, Krampe & Tesch-Römer, 1993; Gladwell, 2013).

2.3.1 Strategic Thinking in Chess

Green and Gilhooly (2012, p. 320) consider chess to be an adversarial game because it is played by two chess players one of whom is an opponent. In chess, knowledge of the opponent (i.e., playing strength, playing style, habits, weakness, and personality factors) is an important factor because players spend time preparing for matches and they adapt their approach and opening to the strength(s) or weaknesses of their opponent(s). Hence, Mikhael Tal (1997), a former world chess champion with GOAT status, emphasises that it is also important to take the playing style of the opponent into account when preparing for a new encounter during chess competitions. It is noteworthy that, in 2015, Garry Kasparov (Talk Chess, 2015) was surprised when he realised that he was not provided with the correct information prior to a simultaneous exhibition in South Africa.

Kasparov was not informed that one of the exhibition group chess players (of thirty relatively weak chess players all with Elo ratings below 1600), was a strong international master with an Elo rating ofover 2200 (Elo, 1978). This international player was indeed someone to be reckoned with; therefore, one can assume that this is also a very important factor in chess excellence. Subsequently, by withholding this information from Kasparov, it prevented him from planning and preparing properly as well as saving time during the match (also see Kasparov, 2017).

Bluff techniques and other psychological strategies besides chess strategies also form part of the chess game. For example, if a chess player made a mistake or a bad move, or if a player thinks that he can possibly be losing a chess piece or match, it is preferable to keep a straight face, to suppress any impulses and intentions to alert the opponent as the opponent may not have noticed the mistake, or the opponent may make an even more critical mistake. However, young inexperienced chess players usually struggle to make use of bluff techniques and to inhibit their emotions (Subotnik, 1993; Dewang, 2023).

Vishwanathan Anand in The Hindu (2022, June 6) mentions that there is more creativity in chess than ever before (see also Sahin, 2017). Anand opines that while Carlsen, Caruana, and Jobava are among the most creative players in the world, innovation and creativity have not changed. It is probably due to that which the computer presents, for example more complexity or more options of possible moves, that the player is forced to think more to find the relevant answer (also see Dewang, 2023; Sihan, 2017; Soloway, Adelson, & Ehrlich, 1988; Gobet, 2011). It is possible that chess experts are not only very creative, but that they also make use of their well-developed intuitive abilities when selecting moves in a chess game (Gobet, 2017; Gobet & Chassy, 2009; Gobet & Sala, 2019).

Certain studies have also explored the extent to which learning and playing chess can improve business intelligence or strategic thinking in a managerial context (e.g., Cannice, 2013). Therefore, chess is cognitively complex not only because of its inherent computational complexity, as well as its gene and environmental factors but also because of strategic thinking and knowledge of the opponent are very important factors in the game (Eysenck & Keane, 2020; Gobet & Sala, 2023). Due to the complexity and cognitive difficulty of the chess game, the cognitive processes associated with chess, and particularly the connection between chess and intelligence, have been greatly researched in the cognitive sciences. In the next section, the focus falls on chess and cognitive dimensions of expertise, theories of intelligence, and a possible ideal time or age to offer chess playing to young children, followed by a conclusion.

2.3.2 Cognitive Perspective Taking

Piaget (1983) studied a child in his own environment. According to Piaget (1980/1952), in humans, a theory of mind, rather than a theory of behaviour, refers to the understanding that a person (a child) can hold a false belief developed between the ages of 3-4 years and is fully developed at the age of five (Guntz, Balzarini, Crowley, Dessus, & Vaufreydaz, 2018; Spratling, 2017; Spratling& Johnson, 2006). Hence, a first order development occurs at age 3 – 5, a theory of mind, in which the child realises that other people hold different beliefs, desires or emotions than oneself. Thereafter, a second order development occurs at age 5-7, when the child can think what other people are thinking about, which involves predicting what one person is thinking or feeling about what another person is thinking or feeling. All these stages (diverse beliefs, access to knowledge; false beliefs, and hidden emotions) are consistent across cultures but the order in which they develop varies according to the values emphasised by each culture. Theory of Mind, allows one to attribute thoughts, desires, and intentions to others with the aim to predict or explain their actions and to posit their intentions (also see Premack & Woodruff, 1978; Astington & Dack, 2008; McHugh, Barnes-Holmes & Barnes-Holmes, 2004).

Furthermore, Premack and Woodruff (1978) propose two types of theory of mind, representations of the cognitive and affective functions. The cognitive theory of mind refers to mental states, beliefs, thoughts, and intentions (as explained by Piaget, 1983), and the affective theory of mind concerns the emotions of others. Then three (more) theories of mind, namely identity theory (or reductive materialism), functionalism, and eliminative materialism are being described by researchers (also see Brown, 1987). Hence, the major debate in the theory of mind concerned the question: 'Which materialistic theory of the human mind is correct?' (Astington & Dack, 2008; McHugh et al., 2004). Certainly, to develop perspective taking, one must progress through different stages according to some theories.

Humans explain their own actions by referring to their beliefs, desires, and other mental states, and consequently attempt to interpret and predict other people's actions by considering their mental states. Thus, such mentalistic explanations or mentalising, interpretations, inferences about others mental states, and predictions of human behaviour are fundamental to social interaction. The theory of mind is therefore an important part of social cognition.

All these stages (diverse beliefs, access to knowledge; false beliefs, and hidden emotions) are consistent across cultures but the order in which they develop varies according to the values emphasised by each culture (Astington & Dack, 2008). It is also important to note that parents in different cultures may emphases different aspects in the teaching and learning approaches provided to children, to ensure that they engage in appropriate interactions with others and learn the culturally relevant social skills and behaviour.

According to Gao et al. (2019), researchers often think of chess as an iterative process of putting oneself in the opponent's mind, by guessing forthcoming chess moves and making inferences of another's mental states (De Weerd, Verbrugge & Verheij, 2017). Hence, playing chess involves reasoning iteratively about the opponent's potential intentional choices, and furthermore, neurologically playing chess and performing a perspective taking task, involve the same brain areas (Westby & Robinson, 2014).

According to Gao et al. (2019), young, experienced chess players (ages 11-12) have shown advanced visual perspective taking. The findings in Gao's study suggest that long-term chess experience might be associated with children's more efficient perspective taking of the viewpoints of other people without exhausting/depleting their cognitive resources. The reason for the importance of perspective taking is that, in chess playing, there is only one player (oneself, against oneself), because a player thinks for himself (and moves accordingly) and simultaneously predicts and thinks for the opponent, which is mentally a very challenging activity due to the switching of focus-points. In educational settings in class or in chess instruction, perspective taking also takes place when skilled or expert educators or trainers instruct learners according to their own abilities and needs (Ogneva, 2017; Whitehead, 1929). Trainers assess, where possible, on what educational level a child functions, what their capabilities are, how the child thinks, what is the best learning method for the child, and what are the best exercises for this child, where humanly possible, and by doing so the instructor adheres to the requirements of Ericsson and Lehman (1996) and Ericsson (1988).

According to Spratling and Johnson (2006), perspective taking differs from theory of mind, but some researchers regard them as being the same. If a person argues that their perspective is the single greatest aspect of their uniqueness, this ability can also be regarded as the foundation for one of the most powerful tools through which they can relate to and build relationships with others. They also expand their own perspective by learning from the way others see life. Moreover, by respecting the perspective or habits of others when offering them empathy is crucial for their development, because empathy is important for their development on both the personal and professional levels. This occurs through perspective taking of the act of perceiving a situation or understanding of a concept from an alternative point of view.

2.4 Chess and the Cognitive Dimensions of Expertise

Various researchers have investigated the differences between experts and novices in chess. Expertise is both a construct and research strategy that is extensively used in cognitive psychology to gain understanding of the cognitive demands associated with complex knowledge-rich domains. For example, in the context of chess, a researcher may want to know, what (e.g. characteristic, skill or habit) sets very good players, or experts, apart from ordinary chess players (De Groot, 1946; 1978; Elo, 1978; Gobet, 2016; Gobet et al., 2011; Persky & Robinson, 2017). According to certain researchers the high official ratings of chess experts reflect their chess skill, and it is indicative of the number of chess games that they have played and won in competition-level play during a certain year (Charness, et al., 1996; Ericsson, 1988). Thus, some of the many characteristics or processes differentiating chess experts from novices or amateurs, are the following: experts or highly skilled people know more (than less skilled people or chess players) and they have strong networks; their knowledge is better organised and integrated in large elaborate domain-specific knowledge bases; they are excellent problem-solvers because they have better strategies for accessing knowledge and using it; they are self-regulated and life-long learners; they make use of perspective taking; and they have different motivations than less skilled chess players, to mention some of the differences (Bédard & Chi, 1992; Eysenck & Keane, 2020; Malamed, 2009).

In the next section more information will be provided about differences between experts and non-experts, with the purpose of establishing what knowledge, problem-solving abilities or processes are needed to become an expert in the chess domain (Gobet, 2017), and moreover, how these differences can impact chess instruction in future, as well as the course and curriculum in chess playing and in educational settings.

Problem solving in chess playing is typically assessed by using knowledge-rich problems (Eysenck & Keane, 2020). Expert chess players possess greater cognitive ability and far more template-based and chunk-based knowledge (also see Gobet & Simon, 1998, Gobet 2016; 2017). This knowledge permits expert players to identify good moves quickly. In the process of achieving excellence in a domain, expert problem-solvers also demonstrate some of the characteristics of creative, intelligent, and highly intuitive people by displaying much self-confidence; they have high degrees of intrinsic motivation; they make use of cognitive perspective taking and they possess the ability to persevere despite of failure or adversities (Gliga & Flesner, 2014; Goleman, 1995; Sahin, 2017). It is also relevant to point out that the experts' motivation focuses on mastery, which is also associated with persistence to work to achieve their goals (Persky & Robinson, 2017).

Chess experts are very successful in decision-making and exhibit selectivity and accuracy in generating solutions, probably due to seeking greater understanding of the problem initially, and due to their good metacognitive skills while solving it (Kazemi, Abad & Yektayar, 2012; Brown, 1987).

Brown (1987) divided metacognition into two main categories, namely knowledge of cognition and regulation of cognition (Bilalić, et al. 2008; De Groot, 1978, p. 125). In a study carried out by Kazemi et al. (2012), it was revealed that the chess players (in a treatment group) showed greater achievement in both metacognitive abilities (a difficult exhausting process) and mathematical problem-solving capabilities (also a difficult subject or field) than the non-chess playing learners after being exposed to chess classes. Hence, when experts regulate their cognitive processes, they are able to make better and more accurate evaluations of board and chess positions than those of novices (De Groot, 1946; 1978). They are also able to calculate the results of tactical combinations (see also Eysenck & Keane, 2020, p. 663; Holding, 1985; 1989; 1992; Klein & Peio, 1989).

Experts focus on principles in their domain, they try to gain a deep understanding of the problem, and may take more time to accomplish the latter to devise a problem-solving-based strategy (Green & Gilhooly, 2012, p. 322). Experts employ a working forwards strategy versus novices who mainly rely on means-end analyses and try to work backwards from what they perceive to be the solution. Moreover, experts plan problem solving by deciding ahead of time how best to use their time and resources, a cognitively scarce commodity (Eysenck and Keane, 2020; Gobet & Simon, 1996). Chess experts (such as Magnus Carlsen) can find themselves in threatening situations while competing, hence, Carlsen will think for a while or longer, and will come up with thinking (and planning) 30 moves ahead and solve a problem in that manner. Chess novices are unable to do so (Eysenck & Keane, 2020).

De Groot, as cited in De Groot et al. (1996) explains that problem solving in chess playing progresses from an external locus of control to an internal mode of self-instruction by the chess player (Eysenck & Keane, 2020). However, researchers differ about the input of educators, instructors and/or coaches at different stages of learning or the acquisition of skills (Gobet, 2012; Waters et al., 2002). Judith Polgar, one of the top 100 chess grandmasters and at one stage the number one female chess player, emphasises that young chess players need help from coaches and chess clubs, as well as a great deal of physical or psychological support in various forms from their parents (Dewang, 2023). Needless to state, adult chess players also require assistance from coaches and assistants.

There are still unresolved issues regarding the structure of the environment necessary to become a chess expert (Gobet, 2012; 2016; 2017; 2020). Gobet advises young children to engage in various sports and to diversify their skills in sports before they concentrate on only one sport (2016). In the chess domain, the possible dangers in a sport can be the minimising of physical activities during chess competitions, and the triggering of physical, emotional, and mental stress (Kottke, 2019).

2.4.1 Perceptual Processing Abilities

In the context of chess, 'perception' represents a form of visuospatial reasoning in which players examine the results of different moves based on the layout of chess pieces on a board. According to researchers (Schunk & Zimmerman, 1997), chess experts routinely apply many of the visual techniques for figuring in technical analyses of sport psychology, for example, an 'eye-walk', followed by a visual search through the consequences of various move sequences. Moreover, experts or skilled perceivers, can make use of goal-directed organised field searches, the construction and manipulation of visual imagery, and mental modelling methods such as chess-specific visual repetitive analyses (De Groot et al., 1996; Eysenck & Keane 2020, pp. 458- 459; Ogneva, 2017).

Humans are capable to regulate their connection with the environment, and the amount of information they want to receive from it (Gobet, 1997; Gobet & Simon, 1996; Kazemi et al., 2012). Chess players make use of the following two processing procedures required for the process of perception, namely data driven (bottom-up) and concept-driven (top-down) processing. Bottom-up processing refers to processing based on environmental information but when context, for example is invoked to identify a stimulus, it is called conceptually driven processing with focused attention during the scanning of a chessboard (Eysenck & Keane, 2020). When chess players do the latter, they draw from their large knowledge bases (De Groot et al., 1996; Persky & Robinson, 2017). After substantial practice, these processes eventually become ingrained and scanning and interpretation can occur almost instantaneously.

According to De Groot et al. (1996), there are two stages of perception in the context of chess expertise, and both refer to a search and evaluation of the chess pieces in the perceptual space. This results in a complex pattern of chess pieces stored in memory, and the spotting of highly informative perceptual features, which includes the selection of a perceptually critical characteristic or a threatened chess piece. The first rule of self-instruction applies to the first stage of perception, when an expert begins to search the chess board in an active search routine during a perceptual search (De Groot, et al. 1996; Eysenck & Keane, 2020). While chess experts perform a more selective search than novices, they do not typically search deeper than chess amateurs but when the task demands it, they can search through different solution paths to great depths and with intense concentration (Gobet et al., 2004; Persky & Robinson, 2017).

De Groot et al. (1996) contend that when chess experts evaluate problem-solving tasks, some of the problems that they view as easy to solve, will be difficult for novices who will regard them as being difficult to solve (Persky & Robinson, 2017), probably due to the presence of large perceptual chunks or templates of information that have to be evaluated (Campitelli et al., 2014; Gobet et al., 2011; Holding, 1985; 1992). Experts also make use of various perceptual strategies in recall and threats can be automatically perceived owing to highly tuned automatisms. Furthermore, there is evidence that experts anticipate where there are difficulties and may then reconsider, evaluate, and encode the information given again and use different strategies to solve the problem (Ferrari, Didierjean, & Marmèche, 2006).

Moreover, when experts perceive, they make use of their powerful, abstract, visuospatial internal mental representations, which they use in problem-solving, when generating moves, or in blindfold chess. Experts are also very quick to generate moves in their mind's eye, according to De Groot et al., (1996). Moreover, structures in the mind's eye can be subjected to visuospatial mental operations and new incoming visual information can be abstracted from them (Chase & Simon, 1973). The latter can contribute to more successful problem-solving (Campitelli et al., 2014; Eysenck & Keane, 2020).

Pattern recognition can happen instantly, automatically, and very quickly in recognising chunks in a board position; hence it is important in problem-solving and in decision-making (Eysenck & Keane, 2020; Gobet et al., 2004; Chase & Simon, 1973). Certain researchers contend that search processes in chess by experts, is more abstract than in the approaches of novice chess players (Campitelli et al. 2014). Pattern recognition refers to each time that an expert comes across a new position, their pre-existing experience helps them to find the right pattern in the new position. After recognition of similarity and pattern, a global strategy can be developed to solve problems and experts can also generate alternative approaches.

Researchers found that students who were placed in an instructional condition that matched their strength in terms of pattern of ability outperformed students who were mismatched. In one of the relevant experiments, a highly-analytical student was placed in an instructional condition that emphasises analytical thinking, and then outperformed a highly-analytical student placed in an instructional condition that emphasised practical thinking (Grigorenko, Jarvin, Sternberg, 2002). An implication of this result is that students should be taught when to use their analytic, creative, and practical abilities, as this could result in improved school achievements for every student, whatever their ability may be.

Experts are also more accurate than less skilled players in recognising chess configurations, which has been theoretically attributed to their very sophisticated networks of knowledge, the discrimination nets, and the huge number of nodes and connections in these networks (Bilalić et al., 2008; De Groot et al., 1996). Researchers maintain that the very fast, almost intuitive type of processing exhibited by experts may thus derive from their superior content knowledge and pattern recognition abilities in a particular domain (also see Gobet & Chassy, 2009).

2.4.2 Expert Visuospatial Abilities.

Various researchers (Campitelli & Gobet, 2005; Howard, 2005; Saariluoma, 1992) consider visual imagery, visuospatial abilities, and visualisation to be important in chess expertise. According to Gobet (1997), findings of a study emphasised the role of long-term memory in expertise and suggests that players use processes that enable them to smoothly combine information from the environment with mental images. Visual imagery is considered to be a link between pattern recognition and move selection, and it plays an important role in learning and problem-solving (also see Nagavalli, 2015). However, little is known about the role it plays in problem solving such as the link between expertise and the use of mental images and how expertise mediates mental images;

therefore, further research is needed in this regard (Campitelli & Gobet, 2005; Eysenck & Keane, 2020).

Waters et al. (2002) postulate that a correlation between chess skill and visuospatial abilities in young children (in young chess players) exist based on three studies (Frank & D'Hondt, 1979; Frydman & Lynn, 1992; Horgan & Morgan, 1990), as measured by performance intelligence psychometric subscales. Gobet and Campitelli (2006), though, warn researchers that such scales do not only relate to visuospatial skills, as assumed by researchers (see also Frydman & Lynn, 1992). They also argue that it is possible that visual memory abilities, and perhaps visuospatial abilities, are important in the early stages of the development of chess skill when domain knowledge is still low but that they are not important in the long-term acquisition of chess skill (Gobet, 2016; 2017).

In the previous section, processing in perception and the early perceptual advantage that experts have over novices were discussed. In the next section, attention is discussed, illustrating how experts can overcome the normal limits of attention.

2.4.3 Attention

Attention is a capacity displayed, especially by experts, and can be defined as a set of processes which one uses to monitor and focus on incoming information in learning. It is thus an essential component of learning (Eysenck & Keane 2020; pp. 231-233; Robinson-Riegler & Robinson-Riegler, 2004). Cognitive resources are focused on certain aspects of the environment rather than others. McDevitt and Ormrod (2013) maintain that young children tend to be quite distractible but as they get older, they become less so. After years of chess practice, the eye fixations of chess experts are faster than those of novices when they direct their attention during a presentation of a position or in the move space (De Groot, et al., 1996). Chess experts also experience lapses in concentration and make mistakes but they are capable of concentrating for much longer periods than novices can concentrate. While experts engage in chess playing, they probably switch their attention between different aspects of the position and they demonstrate heightened attention control or cognitive control by focusing on problematic positions for extended periods (Eysenck & Keane, 2020).

Focused practice enables humans to multi-task when they execute two or three well-learned, non-demanding, automatic tasks at the same time (Eysenck & Keane, 2020). Thus, Hunt and Landsman (1982) contend that more intelligent people may have learned how to use their brains and resources such as time more efficiently than less intelligent people by focusing their thought processes on a given task as well as allocating time efficiently between two tasks (in divided attention) and to perform tasks effectively.

Treisman (1964) posits that, in selective attention, most evidence supports the existence of a bottleneck in processing where the filtering step occurs before incoming information is analysed to determine its meaning (Eysenck & Keane, 2020). Experts are often capable of overcoming such bottleneck constraints in attention and working memory (WM) by developing efficient access to long-term memory (LTM), as predicted by long-term memory-working theory (Ericsson & Kintsch, 1995). It is possible that in the case of chess experts, the new information bypasses short term memory and is directly transferred to the permanent store. In the next section WM is discussed in greater detail.

2.4.4. Problem-Solving and Working Memory

Even though it is important for humans to forget and get rid of some of the information retained in memory stores, numerous cognitive researchers maintain that working memory capacity predicts performance on a wide range of complex cognitive tasks. This also includes measures of general intelligence and practical cognitive skills. Reasoning and problem-solving typically occur in

WM and it entails cognitive processing of relevant information drawn from LTM. This is carried out over a sequence of different knowledge states (Eysenck & Keane, 2020; Drummond, 2000; Mayer, 1990; Melby-Lervig, Hulme, & Redick, 2016).

According to Riana and Nurhayati (2021), many factors may influence the development of sustained attention in children; these include chess instruction and socio-eco-status. Playing chess is a cognitive challenging game that involves the utilisation of various executive functions such as sustained attention, inhibition, cognitive flexibility, and working memory (Aciego, Garcia, & Betancourt, 2012; Bart, 2014; Elkies & Stanley, 2003).

2.4.4.1 Processing and Capacity Limitations in Working Memory. The active WM store is a limited capacity system because information is held in this system for only relatively short periods (Eysenck & Keane, 2020). Therefore, Campitelli and Gobet (2010) argue that time is very important in expertise, and intelligence. For this reason, some researchers (Eysenck & Keane, 2020) postulate that more intelligent people allocate their time more effectively than less intelligent people. They not only spend more time planning for and encoding the problems they need to solve but they also engage less time in the other components of task performance. This is also true regarding the difference between chess experts and novices (Campitelli & Gobet, 2010). It has also been argued that chess experts have more and larger knowledge stores, templates, strategies, characteristics of highly successful people, and automatisms and that they know more than novices do due to excellent interaction between different stores, or direct contact between some memory stores' These factors enable them to overcome capacity limitations in difficult problem-solving scenarios (Malamed, 2009; Persky & Robinson, 2017).

McDevitt and Ormrod (2013) further maintain that problem-solving tasks cannot be effectively carried out when the WM capacity has been exceeded or if the normal limitations of this active memory store has not been overcome. However, some researchers contend that learners can display improved functioning of their respective working memory stores, according to long-term working memory theory, after prolonged exposure to chess classes (Schneider, Gold, Gruber & Opwis, 1993; Scholz et al., 2008).

2.4.4.2 Expertise and Overcoming the Normal Limits of Working Memory. According to Ericsson (1988), chess players require extensive practice and the acquisition of relevant knowledge and skills to attain expertise but, in addition to this, to become experts they must also overcome some of the limitations of WM. Research suggests that experts can achieve this, when they can make use of organisational strategies, namely chunking with pockets of information in chunks, and that exposure to prolonged chess practice of problems eventually culminates in a form of automatic processing (De Groot et al., 1996, p. 102; Lane & Chang, 2018). These automatisms, in turn will enable experts to process information very rapidly and effortlessly (also see Ogneva, 2017).

For example, when certain visuospatial patterns, namely chess openings, are easily accessible to WM owing to practice, this will free up processing resources which can then be devoted to other important aspects of the problem-solving task. It is relevant to note that experts are capable of holding and processing more information about board positions (2.5 pieces on up to five boards) than novices (about 1.9 pieces) in WM (Chase & Simon, 1973).

The following additional factors can also be considered.

Experts possess rich, large, well elaborated knowledge bases which facilitate the transfer of information from LTM to working memory (Eysenck & Keane, 2020, pp. 600-601; Ericsson & Kintsch, 1995). Furthermore, semantic, and procedural knowledge of chess experts are interconnected, according to Campitelli et al. (2014).

These knowledge structures can probably access relevant information via a variety of retrieval cues from WM. For example, when strong chess players memorise most of the 30 best opening moves of the Queen's Gambit, they can quickly process and make moves associated with this opening by releasing resources in WM. Some researchers argue that this type of increased working memory capacity probably applies only to knowledge-rich domains (Ericsson & Delaney, 1998, pp. 104–105; Eysenck & Keane, 2020, p. 293-295; Grabner, 2014).

Some research suggests that becoming an expert in a domain coincides with an improvement in working memory capacity. Thus, Sternberg and Sternberg (2012) also emphasise that intelligence has a strong relationship with WM because intelligent individuals are capable of dividing attention wisely and possess the ability to handle more information within a given period than less intelligent people do (Eysenck & Keane, 2020, pp. 178–183). However, the relationship between working memory and expertise is still unclear in some respects because the direction of the causal connection between them has not yet been fully established.

2.4.4.3 Expertise and Long-Term Memory. The relationship between chess expertise and LTM is now well established in literature (Eysenck & Keane, 2020, pp. 340-341). Experts are generally thought to have acquired extensive domain-specific knowledge of concepts, rules, and patterns in their domains as well as problem-solving abilities that have been refined over many years of practice. The latter is also true of top chess players. However, people experience difficulties when remembering things which they were taught for various reasons, for example, memory loss or missing cues needed to process information (Schacter, 1999). Furthermore, chess experts generally display lower rates of forgetting than novices in the chess domain and they often exhibit an almost immediate understanding of many positions, owing to detailed information about chess positions stored in the permanent memory store (Eysenck & Keane, 2020, pp. 340-343; Gobet & Simon, 1998; Gobet et al., 2004). Therefore, numerous studies indicate that chess experts have excellent memories of board positions and classic chess games (Chase & Simon, 1973; De Groot 1946; 1978; Djakow, Petrowski, & Rudik, 1927).

Gobet and Simon (1996) maintain that strong chess players have excellent recall not only for the positions of the game that they are playing but also for random legal chess positions in chess. Thus, they can accurately recall these positions after being exposed to them for only a few seconds. These experienced chess players seem to have acquired chess-specific knowledge structures, namely retrieval structures which are stored in their long-term memories as a result of extensive chess practice (Gobet & Simon, 1998). Research suggests that chess masters could possess approximately 100 000 chunks of knowledge associated with chess positions which play a role in evaluating combinations and deciding on the best line of play (Eysenck & Keane 2020, pp. 663-664; Gobet, 1997).

When chess players continue to engage in chess practice, they make use of interconnected chunks and large abstract templates or complex data structures, similar to schemas (Gobet 2016; 2017). These templates contain fixed and variable information and experts possess far more templates and chunks than novices. These retrieval structures allow rapid integrative and non-deliberate encoding of board locations into long-term memory as well as quick access to other templates (Eysenck & Keane, 2020, pp. 340-341).

Some researchers would like to know if there are downsides to chess experts or less favourable characteristics (Malamed, 2009). This could certainly be the case when chess experts become trainers or instructors because they can display certain biases such as a metacognitive bias and, consequently, they do not necessarily become good trainers or educators. Chess experts have acquired so much chess knowledge and skills on their road to chess excellence, that it appears to be difficult for them to know ‘how’ (and ‘what’) to teach less skilled or young children in chess classes or clubs, or what these less skilled learners require, despite the existence of three standard stages in chess playing worldwide. In other words, chess experts often do not know how to convey the necessary information so that transfer of learning will take place and thus to enable another chess player to become more competent, or to acquire chess expertise.

Some of the cognitive structures and processes associated with learning and the development of expertise in chess were discussed in this section. The focus of this research falls on how expertise in a complex domain such as chess develops, which does not entail any specific assertion about the relationship between chess, cognition, and intelligence. In the next section, some research about the latter relationship is reviewed, beginning with a brief discussion of approaches to intelligence, followed by a presentation of some research in which the connection between chess and intelligence has been explored.

2.5 Theories of Intelligence

Human intelligence, a controversial and multifaceted (integrating) psychological construct, is a very complex phenomenon; therefore, there are various definitions to describe intellectual development (Sternberg & Sternberg, 2012, pp. 19-20; p. 165; Basson, 2015).

One should bear in mind, that when intelligence is more accurately defined and described, this would be of great help in different settings, for example in educational settings, where instruction in class is based on various aspects of intelligence. Children are also placed in different schools according to their intelligence, and instruction plans must be tailored to their needs (Scholz et al., 2008).

Thus, decades ago, various characteristics were associated with this construct and there have been many models of intelligence. These theories emphasise different characteristics, or processes, namely structures in theories of Spearman (1927: 1863–1945), Cattell (1971: 1905–1998), and Thurstone (1938: 1887–1955), or processes of intelligence, as evidenced in Sternberg's triarchic theory (1985) and Gardner's theory (1993b, as cited in Sternberg & Sternberg, 2012) of multiple intelligences (Carroll, 1997; Jensen, 1998) and each of these theorists have contributed to the understanding of intellectual behaviour.

Intellectual development or intelligence is a theoretically loaded concept and there is no simple agreement among researchers about what it really means. Nonetheless, in chess research, a fairly, traditional, psychometric conception of intelligence is typically adopted, because the main focus falls on measuring intellectual and scholastic skills to assess the learners' levels of intelligence and school readiness, as in this two-stage thesis, which investigated aspects of intellectual and cognitive development. Two ongoing debates in chess research are (a) whether good chess players are generally smarter than average (due to inborn talent or acquired talent); and (b) whether there is transfer of knowledge from complex domains such as chess practice to aspects of cognition, intelligence, or performance in other domains. Alternatively stated, (b) relates to the question whether chess tutoring will exert a positive effect on the cognitive and intellectual functioning of learners and whether it will enhance intellectual skills and school readiness (in the JSAIS and ASB psychometric test) in young children after being exposed to chess classes. Thus, cognition and intelligence are discussed in the next section.

Sternberg and Sternberg (2012) postulate that intelligence or general mental ability for reasoning, problem solving, and learning, integrates cognitive functions such as perception, attention, memory, planning, or language, because of its general nature. Intelligence also refers to a capacity to learn from experience when humans make use of metacognitive processes to enhance learning, and the ability to adapt to the surrounding environment, as done by chess experts (Legg & Hutter, 2007; Sternberg & Detterman, 1986 as cited in Sternberg & Sternberg, 2012).

Furthermore, contemporary experts emphasise the importance of cultural variables, and they point out that what is considered intelligent in one culture may be considered less intelligent in another culture. Thus, it may require different adaptations from humans within different social and cultural contexts (Serpell, 2000, as cited in Sternberg & Sternberg, 2012). The number of existing cultural differences in the definition of intelligence "is termed cultural intelligence" and the latter describe the ability of a person to adapt to a variety of challenges in diverse cultures (Grigorenko et al. 2002; Sternberg & Sternberg, 2012, p. 18). One should bear in mind, that when young developing learners are assessed, for example, to assess scholastic skills for 'subject choice' in high schools (for placement purposes) or to assess concentration skills in learning, various psychometric tests can be used, to provide a more holistic picture of the specific learner's cognitive abilities (Sternberg & the Rainbow Project, as cited in Sternberg & Sternberg, 2012, p. 22). Moreover, Grabner (2014) maintains that personality variables are related to intelligence, hence a comprehensive definition of intelligence incorporates many facets of cognition.

More intelligent people tend to be superior in processes such as divided and selective attention, working memory, reasoning, problem solving, and concept formation. Consequently, the bases of individual differences in human intelligence are better understood when people understand the mental processes involved in each of these cognitive functions. For this reason, a little history will be covered to achieve a better understanding of a complicated concept such as intelligence.

Three cognitive models of intelligence particularly useful when human intelligence is being linked to cognition, are now offered and discussed, namely Carroll's three-stratum intelligence model, Gardner's multiple intelligence theory, and Sternberg's triarchic theory of intelligence (Sternberg & Sternberg, 2012).

2.5.1 Carrol: Three-Stratum Model of Intelligence

Intelligence comprises a hierarchy of cognitive abilities with three levels (Carroll, 1997), according to the three-stratum model of intelligence:

- Stratum I include many narrow, specific abilities, for example speed of reasoning and spelling ability;
- Stratum II includes various broad abilities, namely crystallised intelligence or ability, fluid intelligence or ability, short term and long-term memory and retrieval, information-processing speed; and
- Stratum III refers to a single general intelligence, sometimes called *g*.

According to the Stratum II, fluid ability refers to "speed and accuracy of abstract reasoning, especially for novel problems" (Sternberg & Sternberg., 2012, p. 19). Moreover, according to Cattell (1971), crystalised ability is accumulated knowledge and vocabulary. Caroll also includes several other abilities in the Stratum II, namely learning and memory processes, visual and auditory perception, verbal fluency, and speed, which includes speed of response and speed of accurate responding. This model is probably the most widely accepted measurement-based model of intelligence. Howard Gardner's (1993b, 1999, as cited in Sternberg & Sternberg, 2012) theory of (multiple) intelligence follows below.

2.5.2 Gardner: Theory of Multiple Intelligences

According to this theory, intelligence comprises multiple independent constructs or, rather, "eight distinct intelligences that are relatively independent of each other", such as linguistic, logical-mathematical, spatial, musical, bodily-kinetic, intrapersonal, and interpersonal intelligences and naturalistic intelligence (Sternberg & Sternberg, 2012, p. 19). All the systems in this theory, emphasising separateness of the various aspects of intelligence, can interact with one another to produce what theorists regard as intelligent performance. The base of evidence which Gardner relies on, is the following: a) on the existence of experts in one area; b) on brain regions/legions that destroy a specific kind of intelligence in brain injured people, or c) on core operations that are essential to performance of a particular intelligence (Gardner, 1980; 1983; 2006, as cited in Sternberg & Sternberg, 2012, p. 19).

The logical-mathematical intelligence and logic-spatial intelligence of Gardner (1993b, as cited in Sternberg & Sternberg, 2012) is probably more applicable to expert chess players or the triarchic theory of Sternberg, specifically with reference to the creative and analytical aspects of intelligence (Sternberg, 1985). Gardner (2006) shifted the paradigm and ushered in an era of personalised learning. He also postulates the nurturing of five (distinct) minds (in children) that must be cultivated for success as workers or as good citizens of their society in the twenty-first century, namely the disciplined mind, the synthesising mind, the creating mind, the respectful mind, and the ethical mind (Davis & Gardner, 2012, a cited in Sternberg & Sternberg, 2012).

However, hard evidence for the existence of these separate intelligences of Gardner has yet to be produced. Moreover, certain scientists question the strict modularity view of the mind underlying Gardner's theory (Nettelbeck & Young, 1996). To mention one example, this is evident when one considers the phenomenon of the specific cognitive functioning in people who have been diagnosed with autism. Although these children display severe social and cognitive deficits, they can be very intelligent and in general, children on an autism spectrum take to chess playing, partly because chess has set rules and structure, and requires little social interaction. Thus, there may be reason to question the notion of intelligence as consisting of multiple inflexible modules**.** It may be that Fodor's (1975; 1980) notion of inflexible modules is being conflated with Gardner's notion of multiple types of intelligence at this point.

However, with regard to the eight types of intelligences in children as posited by Gardner (1980), a child may show a natural inclination or mastery in one or more of these areas, which should be foundational to structuring their future and this theory can be very useful in educational settings (Mart, 2013a).

Sternberg's (1985) triarchic theory of intelligence is discussed in the next section.

2.5.3 Sternberg: The Triarchic Theory of Human Intelligence

Robert Sternberg tends to emphasise the extent to which the various aspects of intelligence work together in his theory on human intelligence (Sternberg, 1985). According to Sternberg's triarchic theory, intelligence comprises three interrelated abilities, namely creative, analytical, and practical (aspects). In all three of these, problem solving occurs, but it may require different actions or applications. Creative abilities or skills are used to generate new novel ideas, analytical abilities or thinking are used in familiar problem solving with the purpose of working out if the ideas (of the individual and those of others) are good ones, and in practical abilities, skills are used to put these ideas into practice and persuade other people of their value (Sternberg & Sternberg, 2012).

Thus, cognition is at the centre of intelligence, and Sternberg & Sternberg (2012) posit that the several different information processing models all share the same basic idea. The triarchic theory has much evidence to support it, and the scientific community widely accepts it (Bouchrika, 2024). According to one of these cognitive models, intelligence is based on the ability to take in, process, and store incoming information. Furthermore, the information processing theory of intelligence can be viewed in terms of three different kinds of highly interdependent components.

First, the meta-components refer to higher-order executive processes used to plan, monitor, and evaluate problem solving. Second, the performance components refer to lower-order processes such as perception, used for implementing the commands of the meta-components. Third, the knowledge-acquisition components encompass the processes used for learning "how to solve problems in the first place" (Sternberg & Sternberg, 2012, p. 21). According to researchers (Grigorenko et al. 2002; Sternberg & Sternberg, 2012), teaching students who used all the stated abilities in this theory in class has resulted in improved school achievement for every learner in their classes. However, Sternberg and Kaufman (1996) suggested that a need arose for changes in the assessment of intelligence, probably also due to certain intelligence measures regarded as being one-sided (like this theory under discussion) and because it mostly measures analytical abilities.

2.5.4 Goleman and Hutchins: Emotional and Distributed Intelligence

Numerous other theories of intelligence have been developed by researchers to focus on various other aspects associated with intelligence or that which is regarded as intelligent behaviour (see Gottfredson, 1997; Guntz, Balzarini, Crowley, Dessus & Vaufreydaz, 2018). Goleman (1995) reminded fellow-researchers that emotions can also affect human behaviour, as in his theory of emotional intelligence. In this theory, the interpersonal aspects of intelligence are stressed, and the ability to sense or predict the emotional reactions of others can guide thinking and behaviour. Moreover, Hutchins (1995) also proposed a theory, that of distributed intelligence which is an ecologically orientated theory. It is described as a form of collective intelligence in which components of the overall task are spread out or distributed among a group of agents or learners. In a classroom, one computer, television set or a chessboard and chess pieces can be used for all the leaners or chess players with the aim of enhancing the understanding of a certain topic, for example, in the chess game.

In the next section the possibility of ‘an ideal time to expose young children’ will be discussed.

2.6 The Existence of an Ideal Time to Offer Chess Instruction

Researchers in general differ about the starting age or ideal time for engaging children in chess instruction or training, for various reasons. It is evident that many factors are relevant and must be taken into consideration, and some of these are mentioned briefly in the next section. The starting age definitely depends on the different purposes and reasons why parents or schools want to expose children to chess playing. For example, a general belief of many parents who want their children to receive chess classes, is that chess playing will save or remedy poor education or improve important cognitive or academic skills, particularly mathematical skills. The same idea underlies the promotion of chess by schools and various stakeholders (also see Luneta & Giannakopoulos, 2016; Trinchero, 2013). There is some research supporting the value of chess as an ancillary tuition tool in school settings. For example, in one study slightly intellectually impaired learners in Europe with an IQ lower than normal, approximately 90, were given chess classes (instead of math classes) to assist with their mathematical education, and this yielded positive effects and improvements in their numeracy skills (Scholz et al., 2008). However, Gobet and Sala, (2023) caution researchers against this practice and suggest that researchers should rather retain traditional mathematics and make adjustments because many other variables could contribute to significant (chess) effect sizes, namely a motivation factor due to the manner in which a trainer presents the classes (which probably was the case in S1) (see Section 6.7). Others believe that an early starting age is important to reach time-consuming expertise inthe chess domain (Section 2.6.3).

2.6.1 Specific Characteristics in Young Children

Young children display a higher incidence of synaptogenesis, up to a certain age, and when children are more exposed to new learning material, activation in the brain increases and the speed of firing signals improves rapidly (Bruer, 1999). Furthermore, preschool and young children in general are very curious and keen to learn and explore the world (Piaget, 1980/1952).

Ogneva (2017) suggests that children are exposed to chess classes between the ages of six and eight but she maintains that when children experience complications in their development or developmental problems, and they engage in chess playing, they must commence with fewer diverse chess pieces, for example rook chess pieces, with ample chess practice until it becomes automatic. These learners will then be less stressed and can free up more time for problem solving.

Lockhart, Chang and Storey (2002) contend that Grade R learners do not yet possess a holistic picture of, for example, a chess game. Therefore, at a young age, children tend to overestimate their capabilities and memory skills and consequently they will probably not assume that chess will be too difficult for them. Therefore, researchers (Bjorklund & Green, 1992; Piaget, 1980) maintain that when young children are being exposed to new and difficult tasks, it can result in improvement in their self-concepts and self-confidence, which is crucial during the early Foundation phase school years, and this may subsequently enable them to master new tasks (also see Erikson, 1972; Ormrod, 2006). For example, when children engage in new activities such as different games and boardgames on a regular basis, and they receive guidance or positive reinforcements from educators for their efforts, they acquire confidence and belief in their own abilities, which can positively affect their cognitive and intellectual development, later learning, and achievement.

In a pilot study conducted by Parsons (2014), the school readiness of Grade R learners was assessed prior to chess exposure, and it became evident that the learners did not have adequate prior knowledge of basic pre-school content, for example knowledge about shapes, spatial movements, and acceptable classroom behaviour, to name a few. Hence, Parsons could not commence with chess classes and had to explain the necessary Grade R content. Therefore, a chess instructor must assess the level of prior knowledge of young learners before providing chess exposure, because some schools are too quick to assume that early chess tutoring can compensate for normal cognitive development.

However, Gobet and Campitelli (2006; 2007) hold that skills of children are less context specific than those of adults and transfer is more likely in the former than the latter. They believe that chess must be taught to children at an early age when academic and cognitive abilities are at the beginning of their development. That is why chess intervention studies have focused on the academic and cognitive skills of children rather than adults.

2.6.2 Existence of Critical Periods

Some researchers argue that, in human development, there are critical periods for the development of different abilities or characteristics (Ormrod, 2006, p. 21; Section 3.6.2). Thus, Gobet and Campitelli (2007) argue that a critical starting age for chess playing exists due to a correlation between chess skill and the age for engaging in chess playing. The reason is that at a neuronal level, reduction in plasticity and the consolidation of anatomical circuits occur at the age of twelve (Campitelli et al., 2014). The reason for the critical period in chess playing could be partly due to the neural plasticity in young children as well as a correlation between chess practice and chess skill (Section 2.1.4).

Young chess players want to accumulate the desired amount of chess practice to acquire chess expertise as soon as possible during a critical period. However, according to Gobet and Campitelli (2007) and Ogneva (2017), the slower player may need eight times as much practice to reach master level than the faster chess player. It should also be noted that some researchers do not agree with the notion of a critical starting age (Charness et al., 2005).

2.6.3 Historical Factors

Many famous Russian (or American) world champion chess players started to play chess at the age of four but Ogneva (2017), also a Russian chess player and trainer, prefers children to be six to eight years when they start to play chess (Gobet & Campitelli, 2007).

In 1987, researchers maintained that the starting age for national chess players was 10.3 years and 7.25 years for international players to accumulate the necessary years of chess experience required for chess expertise or to become grandmasters (Doll & Mayr, 1987; Gobet, 2016)**.** With the existence of all the child prodigies, namely Magnus Carlsen, and the neural plasticity in young players, these starting ages may have to be rethought.

2.6.4 Capability of Reasoning Rationally

Halford, Wilson and Phillips (1998) argue that when children are exposed to chess instruction, they must be older than five years because children in general are then capable of reasoning relationally, integrating multiple relations, and making inferences. The latter are all processes implicated in chess. It also depends on in which Piagetian phase the children are when chess classes are being offered to them (Piaget, 1980/1952).

This brief discussion of an ideal time of chess exposure can be useful for stakeholders, researchers, parents, or trainers, and could guide them when exposing young children to chess.

2.7 Conclusion

The aim of this chapter was to furnish a background relevant to determining when a novice or chess amateur progresses through stages to become a chess expert in the chess domain, for this current research investigation. Firstly, a short discussion of acquiring expertise was presented, followed by theories of expertise. Thereafter, a brief review of Piaget's cognitive developmental theory of four stages was presented and the transition from the largely descriptive Piagetian framework to an information processing paradigm in which an attempt is made to explain cognitive processes and mechanisms, was explained. The discussion then moved to chess and cognition, briefly summarising certain research referring to the cognitive and computational complexity of chess. Thereafter, the acquisition of expertise was discussed and research findings related to the effect of expertise in chess on cognitive processes such as perception, memory and problem solving in the cognitive domain were reviewed.

Thereafter a brief introduction to psychological theories of intelligence was given. The literature review suggests that a link between certain aspects of intellectual abilities and chess instruction does exist in children, but not necessarily in adults (Frydman & Lynn, 1992). Lastly, in the case of chess, a theoretically and practically important issue concerns the application of chess as a teaching tool in educational settings to enhance cognitive functioning which possibly also influences performance positively in other academic subjects, was also dealt with in this chapter.

The socio-economic situation in South Africa, coupled with the two educational systems in South Africa are presented in the next, theoretical chapter. Teachers in different developmental schools are compared with one another pertaining to certain variables, followed by cognitive developmental issues. Lastly, research studies that explore the connection of transfer in the context of chess are discussed.

Chapter 3

Theoretical Chapter

In the previous chapter, chess playing and cognition were discussed against the backdrop of human development as viewed by various theorists but mainly by Piaget (1952). Different models were presented to provide theories as possible explanations for chess players to acquire chess excellence. The information processing theory was offered to demonstrate how a 'novice-to-expert-shift' in chess excellence can happen after years of sustained chess practice followed by theories of intelligence (De Groot, 1946; 1978; Sheridan, & Reingold, 2014). The aim of this theoretical chapter is to investigate the socio-developmental and cognitive developmental issues at certain schools in South Africa and to compare the control and experimental schools in their educational environments with one another in historically disadvantaged communities. School readiness in a developing country, such as South Africa is also discussed (Britto, 2012). Thereafter, transfer of knowledge obtained in chess playing from one domain to another, for example, chess and intelligence to mathematics and to reading and verbal aptitudes, is considered. Lastly, chess as an instructional tool is briefly evaluated.

3.1 The Socio-economic Situation in South Africa

South Africa, a developing country that lies between a first and third world country, is rich in natural resources (Bobby-Evans 2015; Van Dyk & White, 2019). At present, the country is suffering a major energy crisis that is crumbling the infrastructure. South Africa has difuse borders, and it is governed by the African National Congress, which has become a conglomerate of different political and cultural groups since the 1994, post-apartheid era (see also Bourgois, 2015; Isaacs, 2012; Marais & Meier, 2008; Mpofu-Walsh, 2021). A huge gap between the richest and poorest has developed and only a certain small proportion of the population pays income tax (Development

Bank in Southern Africa (DBSA), 2017). In 2017, the 78 percent to 80 percent of the total income tax of the country was derived from roughly three percent of the population (Smit, 2023; Worldometers, 2023). The official unemployment rate of the labour force in 2023 was 32.6% and the poverty rate is 61.60%. The country has a heterogenous population which, in 2023, consisted of 60,414,495 inhabitants, with twelve official languages, which places high demands on education in South Africa (Janse van Rensburg, 2015; Worldometers, 2023; Department of Basic Education, 2023). There is a shortage of teachers, a lack of educational progress, and only 20% of public schools are properly functional (Moichela, 2023, Muthusamy & Sayed, 2009). Thus, there is an enormous gap between the results and outcomes of 80% of the schools (Maynier, 2023, May 23; September 18). Moreover, there is a large percentage of school-aged children who do not attend school beyond the primary level, 87% attend school at a secondary level, and only 20%, at a tertiary level. For these reasons, South Africa is typically regarded as a developing country with an oversupply of unskilled workers (Janse van Rensburg, 2015). Only 6% of South Africans have obtained university degrees, and in these modern times, one degree is often not sufficient for employment, and that degree may not mean much in the new highly technological era, according to Business Tech (2022, October 2).

The Thrive by Five Index (2022) reports that for various reasons only one in four, four- or five-year-olds will thrive in South Africa at a time when they should be thriving, which is also an indication that they are ready to learn but cannot achieve this. Britto (2012), and Britto and Limlingan (2012), point out that a lack of satisfactory levels of education is linked with poverty. Education possesses the potential to eradicate poverty and minimise the impact of the three challenges of poverty on human development (inequality, unemployment, and inequality). In the light of the aforesaid, companies in the Krugersdorp and Randfontein areas decided to sponsor chess classes at some of the public schools, for example, the English and Setswana schools. These schools were included in the treatment group, are situated in the areas falling in the scope of this research, and the research also had a social upliftment objective. It is also relevant to point out that many mines on the West Rand had to close, which has further increased poverty in the region.

3.1.1 Education in South Africa

Bell and McKay (2011, p. 27) posit that the pre-democratic era in the educational arena in South Africa was extremely complex and education was divided strictly along racial lines. Thus, in the 1980s, Black and White children did not receive the same educational opportunities and financial allowances which favoured the White learners (Bobby-Evans, 2015; Botha, 2010; Van Dyk & White, 2019). The situation has now changed and a different educational system has been implemented guiding the allocation of funds to children in South Africa not according to racial lines. Unfortunately, there are still many issues to address in school education. The quality of teaching by Black educators was initially of a poorer quality than that of the White teachers in the 1980s owing to differences in their scholastic and tertiary education. Thus, 2.3% of Black teachers nationwide and a third of White teachers had obtained university degrees. Janse van Rensburg notes that, in 2011, only 16.4% of the age group 20 and above had obtained tertiary qualifications and only 16.4% had matriculated, while 34% of the population were regarded as functionally illiterate (Janse van Rensburg, 2015). Studies have shown that 79% of individuals with no formal education were poor compared to only 8.4% of individuals who had completed a post matric qualification in 2015, according to Janse van Rensburg (2015).

Furthermore, prior to 2015, Ona Janse van Rensburg (2015), a senior lecturer of North West University, Potchefstroom, was requested by the Department of Basic Education (DBE) to assess the levels of school readiness of Grade 1 learners owing to concerns by the DBE. The study included all five quintiles (114 learner-participants) in two districts in the north (representing the city) and the south (from a large urban area) of Gauteng (Van Dyk & White, 2019). The teachers and district officials selected the said children whose ages ranged between five and a half to six. The Susan le Roux Group Test for School Readiness was used, which assesses the level of development in different areas of development (Le Roux, 2010). The test consists of visual perception, an incomplete drawing of a person; spatial orientation; number concepts; language and experience: draw-a-person test; auditory perception, and fine motor coordination. None of the five school groups from the different quantiles included in the sample scored at the desired level. This means that none of the five different groups could be deemed to be prepared for formal school as a group. However, some of the individual learners were school ready, even if their group was not (Munnik & Smith, 2019). Age and experience variables were not included in this research, and their effect was not investigated. From this research, it emerged that the teachers had received different levels of training in the two districts.

Although the matric pass rate has improved significantly in recent years in South Africa, the learner dropout rate in schools remains high (Milachila & Moeletsi, 2019; Mpofu-Walsh, 2021). Therefore, the improved matric pass rate cannot be presented as proof of an improvement in the educational domain (Kemm, 2012; Myburgh & Prince, 2014, p. 1).

Jansen (1998a) notes that, since 1994, the Government of National Unity has issued numerous curriculum-related reforms intended to democratise education and to eliminate inequalities in the post-apartheid education system. The most comprehensive of these reforms has been labelled outcomes-based education which was in favour before the National Curriculum and Assessment Policy Statement (DBE, 2023). Botha (2010) explains that the outcomes-based education or OBE paradigm which underlies the 'philosophy of the Curriculum in South Africa'

(2005) focuses on the outcomes of the educational process, and was introduced in South Africa during the last decade as one of the measures to improve the quality of education and to address the demands for an increasingly skilled working force. The OBE model was introduced with the assumption that it would lead to an increase in the quality of education that South African learners would attain in schools and was followed by CAPS (DBE, the National Curriculum and Assessment Policy Statement, 2023).

3.1.1.1 Two Educational Systems in South Africa. There are 52 school districts in South Africa with six in Gauteng (Janse van Rensburg, 2015). The school principals work closely with the district personnel allocated to their school for decision-making, guidance for managing day-to-day crises, and the planning of events. Furthermore, Culture and learning (2023) received the largest share of governmental spending on education, with R387.2 billion in 2020/2021 and R416 billion in 2023/24, according to the National Treasury (2023). According to the Minister of Basic Education of South Africa at the time at the time of writing this thesis, Ms Angie Motshekga, there are still two educational systems in South Africa even though South African citizens live in a post-apartheid era (since 1994) and have experienced more than twenty years of democracy. The well-functioning school system consists of former model C schools and independent schools (the 'wealthy schools' refer to the latter and the Quintile 4 and 5 schools), and a less well functioning school system consisting of the public schools which include Section 21 and no-fee (poorer) schools (Van Dyk & White, 2019; Xabo & Mofokeng, 2021; Bourgois, 2015; Ellis, 2023). Parents, caretakers, or sponsors of learners in former model C schools and independent schools must pay monthly school fees. The public schools of which there were more than 25 000 schools of which 23 000 catered for 12 million learners in 2020 are mainly supported by the government. In theory, there is one school for every

500 learners but this is not so in reality. There are a total of 926 primary schools in all the school districts of Gauteng (Passmark, 2023; Statista, 2022).

The national Department of Basic Education (2023) has interpreted the provision of 12 official languages in one country to mean that learners may select any one of the official languages, namely English, Zulu, IsiXhosa, Afrikaans, Setswana, Ndebele, Sepedi, Sesotho, siSwati, Xitsonga, Tshivenda and Sign language, when attending school. In practice, learners may often live too far from a school of their choice and one which offers tuition in their home language, in which case they will attend the school closest to them.

3.1.1.2 Schools: the process of grading into different quintiles and groups. The size of the grant paid by the government to schools is determined largely by the poverty level of the neighbourhood in which the school is situated as well as the unemployment rate and general education rate of the population in that area. Furthermore, researchers state that, when schools are ranked or graded in South Africa, this is also based on the resources available and literacy rate of the community in which the school is located (Van Dyk, & White, 2019; Xabo & Mofokeng, 2012; Ellis, 2023). Thus, a Quintile 1 ranking indicates that a school is an impoverished school and public schools in quintiles 1 to 3 can apply for a classification as a ‘no-fee’ school. A quintile 4 and 5 ranking indicates that there is affluence in the schools, and the schools may request school fees from parents for learners who attend public schools. No-fee schools normally reside in poverty-stricken areas with parents who have insufficient scholastic and professional qualifications and are most probably unemployed (Spaull, 2013; Spaull & Kotze, 2015). Thus, it could result in failure to provide financially for their families compared with parents of learners in schools that require fees to be paid and who generally have job-related incomes that enable them to support the needs of their developing children.

In 2009, 5% of all schools were (wealthy) Quintile 5 schools and 15% of all schools were Quintile 4 schools. Thus, the aim of equitable funding of public schools is to reduce the disparities in education inherited from the past and to ensure that schools serving impoverished communities should receive more funding (Spaull & Kotze, 2015). However, challenges exist regarding the implementation of the system as well as the calculation base for the allocation of funds for maintenance, and this resulted in inadequate and unfair school funding, which impacts on maintenance, learning, and teaching (also see Bourgois, 2015; Paton-Ash, 2012; Paton-Ash & Wilmot, 2015; Van Dyk & White, 2019).

Furthermore, with reference to public schools, especially no-fee schools, the Department of Basic Education is responsible for all the relevant educational costs in South Africa, for example, the building of new schools and the infrastructure thereof, teachers' salaries and ongoing training, learning material and equipment, and feeding programmes (Muthusamy & Sayed, 2009). The Gauteng government has set aside R6 billion for the construction of new schools to alleviate overcrowding in provincial schools as well as to ease congestion owing to online applications, according to Moichela (2023; also see Paton-Ash, 2012; Paton-Ash & Wilmot, 2015). During the past decades, the government struggled to build enough new schools and to provide more mobile classes when needed. Schools that receive school fees from parents can build and finance new classrooms to an existing school and maintain the necessary daily infrastructure (Moichela, 2023). Since 2022, almost 24,900 schools have been built in South Africa (Moichela, 2023), but the majority of these schools were public entities, covering approximately 90.8 % of the total number of schools (also see Mlachila & Moeletsi, 2019; Statista, 2022).

According to Business Tech (2022, October 27), schools were still struggling with a poor supply of water and sanitation, and 99% of schools in the country had a sanitation infrastructure that was often unusable. The lack of infrastructure in poor communities significantly impacts on the lives of the people living in these communities. Furthermore, the infrastructure and maintenance problems in schools do not only negatively affect academic performance, they also infringe on the right to education, and the right to the safety and health of learners and teachers, according to the DBSA (2017).

Lastly, in 2021, the National School Nutrition Program provided meals to 9.2 million learners at 19 000 quintile 1 to 3 public schools (Steenhuisen, 2023, November 8; IOL, 2021). However, transportation to school and back is paid for by the parents. Researchers reported that learners were transported from townships to inner city schools and it came to light that, in 2017, 13% of learners take an average of 30 minutes daily to get to their respective schools (Bruwer, 2018).

3.1.1.3 Teacher shortages, required qualifications, and lack of training. In the past, the provinces used to differ in their handling of educational matters, for example, Gauteng initially allowed teachers with a one-year diploma in Early Childhood Development (ECD) to teach in Grade R, with the prospect that these teachers would commence with tertiary studies in teaching and complete it within a certain time frame (Garcia & Weiss, 2019; Janse van Rensburg, 2015; Department of Higher Education and Training, 2017).

In 2012, there was a shortage of qualified teachers in South Africa and worldwide (Garcia & Weiss, 2019). According to some researchers, namely Garcia and Weiss (2019) and Dlamini and Maphalala (2021), teachers face challenging conditions in public schools with a lack of resources. At times, they teach in overcrowded classrooms and salaries are often not paid on time. Thus, employment at private schools becomes much more attractive, resulting in an even smaller pool of qualified and motivated teachers for public schools (Statista, 2022). In 2022, in South Africa, the total number of teachers amounted to 450 993, with 15 000 new teachers who graduate per year when close to 25 000 new teachers are needed per year. The situation is exacerbated by the loss of more teachers leaving the profession than those entering it.

Furthermore, the training levels of teachers is also problematic because some researchers argue that the level of school readiness of any learner could improve if the level of the teacher training is good or on an optimal level (Britto, 2012; Bruwer, 2014; 2018; Janse van Rensburg, 2015; Luneta, 2018). Since 2002, when teacher training colleges were either closed or merged with universities and/or technical universities, Grade R training became part of the Bachelor of Education (B. Ed. Foundation Phase) degree (DHET, 2017). However, when students apply for teaching degrees, namely Bachelor of Education in Foundation Phase (90102), lower requirements are deemed acceptable for teaching students than for other degrees; for example, a 60% in mathematical literacy or mathematics is acceptable (Albertyn & Guzula, 2020; Weideman & Van der Silk, 2007). There are differences in salaries between the teachers of Grade R, and the teachers of grades 1, 2 and 3. Therefore, at times, as soon as Grade R teachers qualify, they apply for departmental posts for grades 1, 2 and 3 at schools so that they can receive additional benefits, and this then leads to shortages in the Grade R arena. Another aggravating factor relating to shortages of teachers, is that the absenteeism rate of teachers is high in South Africa, totalling at least 10% of working days or higher, and teachers were absent close to 7.5 million days during 2012 (News24, 2013). It should also be noted that learners' absenteeism is also high, according to researchers (Weideman, Barry, Goga, Lopez, Macum & Mayet, 2007), which can place more demands on teachers.

Two principals of the no-fee schools in this current research study (Stage 2) were always at school and they expected the same from their teachers, with the implication that they are only absent if they are sick or when they are writing examinations. Lastly, according to some researchers, there is evidence of corruption in schools and in the broader educational environment such as union involvement, where teachers can buy jobs (also see Serfontein & De Waal, 2015).

3.1.1.4 CAPS. The aim of the present CAPS curriculum is to lessen the administrative burden on teachers and to ensure consistency and guidance for teachers when teaching according to the week-by-week planning (DBE, 2023). Thus, this multilingual curriculum (in twelve languages) tries to give clear guidance for teaching and learning as well as support to teachers, especially when they are fully qualified (DBE, 2001a). The guiding idea is that teachers will be able to prepare for activities as well as any accessories required for the learners for the following day or even for a week ahead if they follow the CAPS curriculum, and learners have Grade R A-4 Workbooks to work in. Since the pictorial examples of objects or animals in the book are not large enough for Grade R learners, many teachers draw their own pictures and copy them for each of the learners. The teacher or assistant assembles all the necessary accessories or materials needed; for example, brushes and paint for painting, or crayons for colouring in, or wool, feathers, and glue for sheep or birds. However, according to some researchers, the CAPS curriculum is not suitable for no-fee schools, due to their lack of resources (also see Scott, 2019; Mart, 2013a).

There are guidelines for responding to learner diversity in the CAPS curriculum. Thus, the key to managing inclusivity is ensuring that barriers are identified and addressed by all the relevant support structures within the school community, including teachers, District-Based Support Teams, parents, and Special Schools as Resource Centres (DBE, 2023). Lastly, at present, all the public schools follow the same curriculum, namely the CAPS curriculum. The following aspects are integrated in this curriculum.

- **Grade R**

Grade R, a reception year has formed part of the General Education Training Band (GET) since 1998, and is the year before learners in South Africa begin with formal schooling. Since 2022, Grade R has been compulsory and no longer falls under the Social Development Department but rather, the Department of Basic Education (DBE). According to the Education White Paper 5 on Early Childhood Education (DBE, 2001a), the purpose of Grade R policies and programs is to endorse the democratic right of a child to develop their cognitive, emotional, social, and physical potential. The schools that have not yet incorporated Grade R into their schools have had to add additional classrooms or mobile classrooms to accommodate the Grade R learners (Le Cordeur, 2023, February 2; Masemola, 2010). According to the South African Government, 2021, February 10, Grade R learners may enter Grade R at the age of four turning five, by 30 June in the Grade R year. Learners can then turn six in Grade 1, while the age of seven years is in general preferred in (former) model C schools owing to the emphasis placed on learning to read and write (Bruwer, 2014; 2018; Janse van Rensburg, 2015). Learners may fail grade 1 – 3 once during the foundation phase, but not repeatedly as in the past and they may not be refused school entry (Kiki & Kotze, 2019). Applying for school entry is troublesome in South Africa owing to the number of Grade R or Grade 1 learners seeking school entry; therefore, if there is no place available at the desired school, the parents must approach other primary schools. Furthermore, according to Wills (2023), there may be 28 to 35 learners in one Grade R class. In independent schools, one teacher and an assistant are allocated to a class of 15 learners. However, in the latter case, this is so with a maximum of only 35 learners in one class which is not always the case in South African schools; for example, one class in the experimental group had 50 learners in the class (Mpofu-Walsh, 2021).

- **Gender Differences in young learners**

Young boys and girls differ from one another in many ways (Reilly et al., 2022). While they mainly differ physically, they may also differ in early classroom behaviour, superiority in different skills, subject choice, and even career choices when older. Also, as already mentioned, parents in the past wanted to delay entry to school for boys due to their energy and need for movement, especially when in class (Adani & Cepanec, 2019; Carlton & Winsler, 1999; Robinson, Abbott, Berninger, & Busse, 1996). There are also indications that teachers may react differently to boys in class, for various reasons, and there is a fairly pervasive assumption, which may no longer be valid, that boys are normally very good at mathematics and science, and that girls tend to be better in languages or artistic subjects, and can process information faster than boys (Chitiyo, Lastres, Simone, & Zagumny., 2023; Giofré, Cornoldi, Mammarella, & Ronconi, 2013). Thus, there are far more males than females in computer science and engineering jobs in South Africa and worldwide (Ananthaswama & Douglas, 2018). There are putative differences in cognitive aptitudes between males and females, and there are career-choice differences, worldwide between the genders. Thus, males still tend to occupy higher-level jobs and earn more money than females, but this may be changing (Giofré et al. 2013). In fact, there are numerous studies with widely varying results regarding any intellectual, personality-based, or aptitude-related differences between males and females, but these are not of major importance in this thesis (Gesell, 1940).

- **Age differences in young grade R learners**

Some researchers believe that younger (-5 in this current research study) preschool children are ‘less clever or skilled’ than older children (+5) in class due to longer exposure to stimulation with the possibility of them acquiring more skills (Carlton & Winsler, 1999; Janse van Rensburg, 2015; Sallon, 2013). Thus, children had to be assessed to determine whether they were ready for school and if not ready, school entry would be delayed for young children. Determining the age at which young children are ready for school is not that straightforward because young children develop differently from one another and they can grow in spurts (Bruer, 1999). Moreover, some children could receive more stimulation at home and they may attend better preschools which could also influence their cognitive development. Teachers are nonetheless being taught to prepare for older and more mature or skilled learners in class without all the background information they need (Carlton & Winsler, 1999; Janse van Rensburg, 2015). The effect of age differences as an additional variable affecting chess classes as a treatment factor is investigated in the current thesis.

3.2 School Readiness

School preparedness starts early in the lives of children. It is a complex, holistic and bi-directional concept that was not initially perceived as such. School preparedness has received increased attention from stakeholders, academic staff (including teachers), parents, researchers, therapeutic team members, and policy makers, who all view this concept differently; however, they do agree on a few matters (see also Carlton & Winsler, 1999; Lewitt & Baker, 1995; Munnik & Smith, 2019).

Initially, the construct suffered from a narrow, maturationist (biological) theoretical perspective which presents the problem as residing mainly within the child, namely readiness to learn and readiness for school with the implication of readiness being the duty of the school systems. This perspective was based on the Maturation Theory of Arnold Gesell (1940) (see also Lewitt & Baker, 1995). Thus, certain researchers posited that a child’s readiness for school refers to their social and cognitive competencies and skills when entering formal school and which are important for later success in life (Britto, 2012; Janse van Rensburg, 2015).

Furthermore, school entry was treated differently at the time of the mentioned studies, for example, younger boys in particular, were kept at home until they were a little older, probably due to a higher level of energy at a preschool age (Grantham-McGregor, et al., 2007); Mergendollar, Bellisimo, & Horan, 1990). In a country with many official languages, such as South Africa, Clutten (2007) argues that if a child's school entry is delayed, it would be more troublesome if, for example, they struggle to read and receive the necessary remedial help only at a later stage. Moreover, during this period in history, many learners have had to continuously repeat grades (Ohiri, 2023). During the last decade, this has changed and repeating a grade is limited to only a few times during the foundation phase.

Preschool learners also had to almost prove that they were ready to enter school and they were assessed by various school readiness tests. Thus, a paradigm shift was needed, according to Carlton and Winsler (1999).

The cognitive development theory of Piaget (1980/1952) has been recognised in preparing learners for formal school (Section 2.3.3) and within the framework of this theory it is accepted that children between the ages of 18 months and 5 years are capable of learning up to 10 new words daily (Ruben, 1999). Another important change stemmed from Vygotsky's theoretical work. The major theme of the Vygotskian sociocultural theory of human learning, as cited in Mahn & John-Steiner (2012), is that social interaction plays a fundamental role in the development of cognition.

As a result of these developmental theories, the process of cognitive scaffolding by educators or parents, a difficult process, is now regarded as being very important in preparing learners for formal school. Each learner enters the classroom with a complex pattern of emotional, behavioural, linguistic, cognitive, motivational, and physical developmental strengths and weaknesses. Learners, who are not all on the same developmental level, must be exposed to learning situations and carefully assisted by others to develop the necessary skills and ways of functioning (also see Ogneva, 2017; Storey, 2000).

Thus, it is accepted that teacher training should enable teachers to create and develop learning experiences and scaffolds that will allow learners to proceed to subsequent levels. Additionally, perspective taking skills are also acquired from teachers for optimal scaffolding (McHugh et al., 2004). By emphasising the role of the teachers in the readiness of learners, the achievement of successful school readiness can be regarded as a bi-directional process of both the school, which must provide optimal or safe learning environments for learners, and the children who must flexibly adjust to each other (Brewer, 2007; Scott, 2019; Mart 2013a).

Urie Bronfenbrenner (1979; 1989) developed a complex ecological model that explains the direct and indirect influences of systems or role players on the development of individual Grade R learners (Bruwer, 2014; 2018; Janse van Rensburg, 2015). The environment or social context can be conceived to be a set of nested structures or layers in which a child functions and actively participates in their own development (Landsberg, Krŭger, & Nel*,* 2005, p.10). This multidimensional model of human development can assist teachers in their understanding of leaners. It suggests that these levels or interacting systems result in physical, biological, psychological, social, and or cultural change, development, and growth, and that relations among people are reciprocal and multi-faceted. In this model, the teacher plays a key role in facilitating interaction between the school, the parents, and the teaching and learning that occurs in class (Namukasa & Aryee, 2021).

Bronfenbrenner's theory emphasises the importance of positive interactions between the community, family, and school. According to Carlton and Winsler (1999), there is a third type of school readiness that is, readiness of families and communities to help their children make a smooth transition to schools (also see Britto, 2012; Britto & Limlingan, 2012). Some researchers also argue that school readiness is important for national development due to the high costs of the various degrees of inaction for children, families, communities, and countries, with subsequent negative effects for individuals, society and international development (Grantham-McGregor et al., 2007; Schenk-Fontaine & Panico, 2019). In this regard, school preparedness and early school education can be regarded as a proven strategy to improve the economic and social development of a society (Britto & Limlingan, 2012). Some researchers maintain that the costs of inaction for school readiness of individuals and society indicate that the first six years of a child's life are important factors to ensure the future economic well-being and growth in a country (Britto & Limlingan, 2012; Mergendollar et al., 1990).

Worldwide, only fifty percent of countries have a formal system for the care and development of children of three years old and younger (Bruwer, 2014; Grantham-McGregor et al., 2007). However, this is far from ideal when learners are ill-prepared to benefit from the school environment and when they are not ready for school let alone the demands of formal school years (Britto, 2012; Britto & Limlingan, 2012). In sum, there are consequences for individuals, families, society, and international development when learners are not ready for formal school

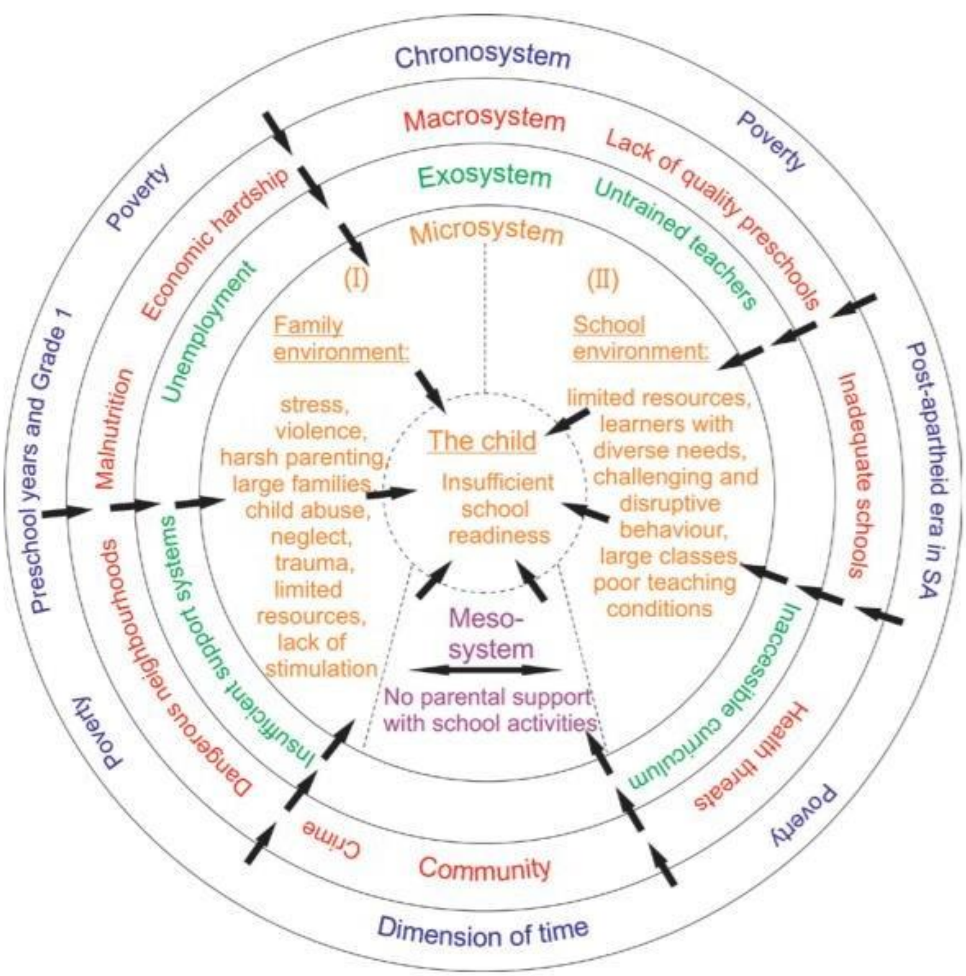
Furthermore, in this research study, the aptitude tests for school beginners have been used, not for placement but to establish a baseline at a pre-condition and a possible improvement at a post condition to indicate whether some learning has taken place.

3.2.1 Model of Bronfenbrenner

Through the lens of Urie Bronfenbrenner, Bruwer (2014; 2018) adjusted a model of a child growing up in a poverty-stricken area, with the aim to gain a better understanding of all the possible influences on a young developing child (Bronfenbrenner, 1979; see also Tong & An, 2023). Figure 3.1 displays the effect of poverty and deprivation on children based on Bronfenbrenner's ecological theory of child development that has been adapted for the purpose of a study by Doctor Bruwer (2014, p. 41).

Figure 3.1

The effect of poverty and deprivation on children through the lens of Bronfenbrenner's ecological theory of child development



3.3. Expertise in the Educational System

In Chapter Two, less skilled chess players were compared with chess experts in a novice-expert shift (De Groot, 1946; 1978; Donovan & Radosevich, 1999; Gobet, 2016; 2017). Expertise also exists in the educational system; for example, there are many principals or teacher experts in the education system who acquire approximately 4 – 6 years of teaching experience to become experts. Expert teachers share many skills of experts in general; for example, the manner in which they perceive, have good working memories, are capable of categorising well, display more critical views, see holistic pictures, and can predict or anticipate problems or difficulties. Expert teachers have good subject knowledge and good teaching skills (Gobet, 2016; 2017). However, none of the student teachers involved in the research of this thesis (Stage 2) in all three schools in the control and treatment groups, had graduated by the end of the time-period; thus, they could not be regarded as expert teachers, (as the teachers in Stage 1, in a former model C school) (also see Scott, 2019). Expert teachers usually teach at a level that is beyond that which is required of them. One way of assessing that is by taking the needs of the learners and the results of their achievements into consideration to provide extramural classes when necessary. Expert or good principals display similar characteristics while their jobs are more demanding.

The three principals in the two groups in the current investigation had obtained diplomas and degrees and decades of teaching experience. Gobet (2016) regards children who are described as ‘expert learners’ as often no more than ‘good learners’, even though they remain highly skilled learners until the age of 17 or 18 when this ability tails off (see also Section 2.1.5). In the next section, the no-fee educational environment of the teacher-students in the control and treatment groups in the three schools is briefly discussed.

3.4 A Comparison of Two Groups in the Educational Environments

3.4.1 The Control Group

3.4.1.1. School, Class Size, Playgrounds, Toilets, and Running Water. The three spacious classrooms with storerooms were separated from the rest of the school in a private Grade R arena surrounded by the playground area where learners played and ate their lunches. The climbing frame had been broken for a long time. There were bookshelves with children's books and educational toys available in the three classes with three television sets in total. Each classroom had toilets and fresh running water with one broken toilet in one of the classrooms which had never been properly fixed. While there were thirty plus learners in each class, they were not overcrowded. There were no assistants in the three classes but, rather, teaching students from the nearby university presented lessons to the learners as part of their teaching curricula.

3.4.1.2 Teachers' Qualifications, Years of Experience, and Ages. The teachers in the C group were much older (41-60 years) than the teachers in the E group (37 - 41 years old). Each of the older teachers had already been teaching for approximately ten years versus the younger teachers who had been teaching for approximately four years only. All the teachers in both groups were in possession of the required one-year ECD certificate but none of the teachers had completed their three- or four-year teaching diplomas or degrees by the end of the time-period. One teacher in each group completed their degrees after the relevant time interval. The teachers in the 'no treatment' group had been exposed to studies and compulsory in-service training by the DBE longer than the younger teacher-students in the experimental group.

3.4.1.2.1. CAPS. The teacher-students who had met the requirements pertaining to the various subjects made use of and followed the CAPS Grade R curriculum which provided lessons. With all their additional non-teaching tasks, their own teaching studies, and having to write examinations throughout the whole year, and no permanent assistant in class, these teachers were not able to adhere to all the requirements and their amount of tutoring time was insufficient. Not enough copied paper worksheets and accessories were available for the daily activities; therefore, the learners mostly worked in their Grade R learner workbooks. The teachers were able to teach the learners individually how to cut with a pair of scissors, probably with the help of the university students who performed some practical work at this school as well as other schools in the surrounding area. Lastly, Grade R is different from the rest of the school grades of the Foundation Phase regarding the required qualifications and salary of the teachers. Play times for Grade R learners are much longer for these young developing children, no formal reading and writing is yet required, and they rely heavily on practising many different skills for gross and fine motor skills in preparation for formal school (Krog & Krüger, 2011).

3.4.1.2.2. Class Management Skills are being taught as a third-year subject for Bachelor of Education students. These teachers were able to manage a class full of young learners as a unit or as individuals after many years of teaching. Thus, it is possible that the more experienced, older teachers may have learnt how to handle their own classes and larger groups more efficiently. Teacher absenteeism was higher in this group; hence when one teacher was absent her class had to be divided into two 'make do' classes, resulting in teachers handling more learners than usual. It is possible that a larger group, which is more difficult to handle, could have watched a film or a programme on a television set. The older group of teachers had been exposed to more in-service training and could have learnt which classwork is the most important to concentrate on, for example, to learn and write the alphabet and numbers, and to present to the learners as witnessed by the researcher when the ASB was administered on two occasions with the help of these teachers.

These teachers were also able to translate English into various African languages for the Grade R learners.

3.4.1.2.3 Additional tasks and responsibilities as a Grade R teacher in a no-fee school. Even though all these student-teachers were not yet completely familiar with the lengthy CAPS curriculum; they had to deal with all their daily tasks and responsibilities, as explained earlier. The teachers have to prepare dough or art activities for each day, assist with sick or hurt children, supervise meals, and assist with administration tasks as well as the planning or placement of learners for the following school year if needed. Furthermore, Grade R learners are always under the supervision of teachers who have no tea breaks in the personnel tearoom when they would be able to interact with their colleagues (Dlamini, 2018; Dlamini & Maphalala, 2021).

3.4.2 The Experimental Group

3.4.2.1. School, Class Size, Playgrounds, Toilets and Running Water. The English school had approximately fifty learners in a large spacious Grade R classroom with toilets, a small playground in front of the class, and no permanent assistant. The Setswana class had thirty plus learners in a small mobile classroom far from toilets and fresh running water, but not far from the Grade R playgrounds, and no permanent assistant. When the climbing frames and equipment broke, there were no funds to restore them. Grade R learners of one school, at times, ate their meals in class because their playground was on the other side of the classroom. To take the learners to the playground, the learners had to line up in a row and had to be accompanied to the playground area.

3.4.2.2 Teacher qualifications, years of experience, and ages. All the teachers in both groups were in possession of the required one-year ECD certificate but none of the teachers had completed their three- or four-year teaching diplomas or degrees by the end of the relevant time-period. One teacher in each group completed their degree immediately after the relevant time-period, and another teacher in the treatment group sadly passed on due to a serious illness. The teachers in the chess group (37 – 41 years old) were much younger than those teachers in the control group (41 – 60); they had been teaching for approximately four years only.

3.4.2.2.1 CAPS. The discussion in Section 3.4.1.2 (with reference to the control group) is also relevant in the experimental group because the teacher-students also supposed to make use of and adhered to the CAPS Grade R curriculum. However, with all their additional non-teaching tasks, these teachers were not able to adhere to all the CAPS requirements and the learners had also not received sufficient tutoring time. The teachers attended in-service training from the DBE, but also from the chess initiative. These teachers were also involved in chess tutoring, assisted by the chess facilitator. Both teachers with classes of fifty and the one teacher with a very small mobile class (and thirty plus children) were not able to teach the learners how to cut with a pair of scissors individually because the learners could hurt themselves without sufficient supervision and space. Hence, the learners could not perform a few of the chess activities that were based on cutting out in the Grade R chess curriculum, because they had not learnt how to master all the required motor skills. It is also possible that these non-expert student-teachers did not acquire the skill to divide their time wisely by teaching some of the learners how to cut while the others were playing outside, as expert teachers would normally do (see Section 2.4.4).

3.4.2.3 Class Management Skills are required by teachers because, before teachers can even present and connect new information to prior or old information, they must be able to manage a class full of young learners as a unit or as individuals, despite not being familiar with a more formal class educational set up. Thereafter, it is a daily task for them to aim to fulfil the needs of each learner according to the CAPS curriculum. One of the teachers in this group struggled to manage discipline in class and moreover she reported that the boys were too active in the small class. While the Setswana teacher was able to translate English into other African languages, the Coloured teacher could not do so. She could speak English and Afrikaans fluently but only a few words in some of the African languages (Marais & Meier, 2008).

3.4.2.3.1. Additional Tasks and Responsibilities as a Grade R Teacher in a No-Fee School. Despite the fact that these student-teachers were in possession of only a one-year ECD diploma, they were not expert teachers, and they had to deal with all their daily tasks and responsibilities as mentioned earlier. The teachers had to prepare for the daily activities or the artwork of the learners to fulfil the needs of the learners, supervise meals, take learners to taxi stands when needed, and assist with administration tasks, as well as teaching chess playing (with the help of the chess facilitator) once a week over a certain period. It is therefore not surprising that the student-teachers in the treatment group in this research investigation expressed that they were feeling burdened (and stressed out) due to all the tasks and responsibilities they had to carry out (Dlamini, 2018; Dlamini & Maphalala, 2021). It should also be noted that a lack of parent involvement in poverty-stricken areas could also complicate educating children in these areas. Lastly, considering that the teachers in the schools in this research study held insufficient Grade R qualifications, lacked real educational experience, were not sufficiently familiar with the curriculum, and experienced insufficient funds for printing the daily worksheets for up to 50 learners, they found it difficult to prepare learners for formal school, and thus to ensure that learners be successful in life when older (Isaacs, 2012).

3.5 Summary

All the teachers in Stage 1, were qualified with a three-year diploma or a four-year degree, and they were all expert teachers, who have taught for more than four years, and they knew the CAPS curriculum well, in a former model C-school. All the teachers in Stage 2 of the thesis, in developing schools in West Rand and Mamelodi, had a one-year ECD Diploma and they were all studying for a teaching degree or diploma. The teachers in the control group were older and probably wiser than the teachers in the experimental group and furthermore, the teachers in the control group had been more exposed to in-service educational training than those of the treatment group during all their years of teaching. Hence, the teachers in the C group displayed better or more advanced skills than the teachers in the E group. Pertaining to the chess initiative in the West Rand, the control group in Mamelodi was not involved in chess tutoring at school, which could have placed fewer demands on their day-to-day teaching. Lastly, it is possible that the teachers who were exposed to chess training or classes, could still reap the benefits therefrom in the future, which was not been assessed to date.

3.6 Cognitive Developmental Issues in South Africa

The aim of the next section is to identify and discuss cognitive developmental issues in South Africa.

3.6.1 Poverty, Low Intellectual Levels, and Poor Concentration Skills

Some of the main victims in the ongoing struggle with poverty are children (aged 17 years and younger), Black Africans, and those with little or no education (see Bourgois, 2015; Schacter, 1999; Schenk-Fontaine & Panico, 2019; Spaull, 2013). Growing up in poverty is one of the greatest threats to healthy childhood development and, moreover, it entails more than the loss of income and product resources to ensure sustainable livelihoods (Isaacs, 2012). A few of the manifestations of poverty include hunger and malnutrition, limited access to education some of which is inferior education, and other basic services (Bruwer 2014; 2018; Landsberg et al., 2005). The long-term effects of poverty include chronic illnesses which can lead to further health problems (see also Britto & Limlingan, 2012). Lastly, poverty also leads to a set of cultural attitudes, beliefs, values, and practices; for example, teachers who grow up and teach in poverty-stricken areas (Bourgois, 2015), and this culture of poverty would tend to perpetuate itself over time, even if economic conditions that gave rise to this situation were to change. Thus, some of the researchers explain (Le Cordeur, 2023, July, 31), that if so many of the young learners are stunted, malnourished, and still hungry, despite receiving meals at school, these learners display poor concentration skills and low intellectual levels (Ferguson, 1998b). Furthermore**,** teachers noticed that the Grade 1 learners in inner city schools were very sleepy in class and they could not concentrate well (Bruwer, 2014; 2018). Moreover, certain researchers have posited that Grade R (young) learners were extremely tired after they had completed school readiness tests despite the breaks they were given (Bruwer, 2014; 2018; Janse van Rensburg, 2015; Parsons, 2014).

Lastly, it appears that Grade R learners have poor prior knowledge due to insufficient stimulation at home, coupled with insufficient levels of teaching. This could have negative effects on their neural development during the brain plasticity period, which could also impact negatively on cognitive development leading to poor memory and concentration skills (McDevitt & Ormrod, 2013; Sternberg & Sternberg, 2012).

3.6.1.1.1 Insufficient Levels of School Readiness (in Groups) in No-Fee Schools. Grade R learners in various studies or groups, excluding independent and former model C schools, were not school ready in Grade R or Grade 1 (Bruwer, 2014; Janse van Rensburg, 2015). In the investigation undertaken by Janse van Rensburg on behalf of the DBE as a result of concerns, none of the five school groups of Grade R learners from across quantiles one to five and from two districts in Gauteng, scored at the desired level of School Readiness. This means that none of the five different groups could be deemed to be prepared for formal school as a group. However, some of the individual learners were ready for school, even if their group was not. Age, ranging from five and a half to six years, and experience variables, were not included in this investigation.

Teachers had different levels of training in the two districts, as well as in the two stages of research in this thesis. In the Parsons pilot study in 2014, the learners who were exposed to chess instruction performed significantly better than the controls, indicating that there is clearly a need for better qualified teachers for learners in the preschool years in South Africa (Janse van Rensburg, 2015). A well-grounded training programme for teachers of five- to six-year-olds will contribute to the bridging of the SR achievement gap and could lay a firm foundation to ensure the future learning success of these learners (Mart, 2013a). Teachers with levels 1, 4 and 5 training should be allowed to be only assistants to trained pre-primary school teachers. Considering that the research shows that teachers lack suitable qualifications to teach Grade R learners, an intervention programme should be developed as a guideline. Furthermore, some of the worrying factors pertaining to education, are mentioned below (Kemm, 2012; Myburgh & Prince, 2014, p. 1).

3.6.1.2 Poor Literacy and Illiterate Behaviour. Some of the researchers, (Le Cordeur, 2023, July 31), explains that it is not logical to expect, for example, that Grade 4 learners who turn 10 years old (and who suffers from malnutrition) must be able to ‘read without understanding’ (also see Le Cordeur 2023, February 2). A research study of The Progress in International Reading Literacy Study in 2021 indicates that these learners are incapable of reading with understanding, due to various reasons (Luneta & Legesse, 2023). This assessment was administered in South Africa, which is of course a country with the second most different official languages (Zimbabwe have the most), amongst the many multicultural countries in Africa. The assessments were administered in different languages at the end of 2021 during October to November (Le Cordeur, 2023, July 31).

One should bear in mind that Foundation Phase learners took turns to attend classes at school after Covid-19 (in South Africa), and more attention/teaching was afforded to Grade 12 learners (Van den Berg, & Spaull, 2020). Furthermore, if so many of the learners are stunted, malnourished, and still hungry in the Western Cape, how can one expect them to be able to read with understanding (Le Cordeur, 2023, July 31)? Hence, despite receiving two meals at school, these learners display poor concentration skills. Another factor is that learners switch from their home language to mostly English in schools in Grade 4, and when the learners are tested in Grade 6, their knowledge of a difficult language such as English is not yet satisfactory (Luneta & Legesse, 2023). Prof. Le Cordeur made a few suggestions, namely that learners should be firstly taught the 'love for books' rather than how to read a difficult language with meaning and that more time must be allocated for reading in class. Thus, poverty in South Africa is coupled with many other characteristics such as a poor literacy rate in the country. The literate behaviour was 47% in 2013, which does not refer to only the ability to read but also to the amount of reading hours per day and the number of libraries (in public schools) in the country. Moreover, the adult literacy rate (of approximately 87%) is much lower than the literacy rates of, for instance, the eastern countries (namely Singapore) with literacy rates ranging from 95 – 100%. Studies carried out by the DBE (2013) have already indicated that many primary school learners read without understanding, which is not all due to the pandemic and lockdowns. In overcrowded classes in South Africa, one way of handling this difficult situation is to concentrate on content rather that comprehension.

Furthermore, libraries are essential pillars in democracy. They afford everyone with access to sources of information of all kinds in the generation of new knowledge and opportunities to effectively use such information. Libraries also grant the learners additional reading opportunities which in turn would improve their reading skills, comprehension, and writing with better clarity of expressions. In turn, such skills would support student performance in all their other curriculum subjects (Paton-Ash, 2012; Paton-Ash & Wilmot, 2015). Learners, however, reported that very few of them have books (or magazines) at home and most of their parents do not read well. In 2011, 21% of 24 793 state schools had libraries, according to DBE (2011a), and in 2016, 70% of schools in South Africa still had no libraries and fewer than 8% of schools had adequately functioning libraries (see also Paton-Ash, 2012; Paton-Ash & Wilmot, 2015). Moreover, there is no national policy for school libraries and librarians and no prospective plans to rectify this situation are in place.

This scenario, thus, compels members of school governing bodies and principals to establish libraries in their schools. While the control (Sepedi) school in the current thesis (Stage 2) had a library, the school also used it for staff meetings or as an office. In the Western Cape, more finances are allotted to various projects, but also to reading programmes, according to Le Cordeur (2023, February, 2), but the situation is much worse in some regions of Gauteng, such as the areas where this research was conducted.

3.6.2 Language and Language Barriers

The notion in various culturally diverse African countries is to have only one to three official language(s) in one country and, understandably not twelve, owing to additional demands on the educational systems in a country (Suryanto & Sari, 2021). In this research study teachers noticed and reported that some Grade R learners experienced language barriers in communication since learners and the teacher spoke different languages and could not understand one another in any of the languages that the teachers or the learners knew; hence a breakdown in language and communication occurred (Landsberg et al. 2005). In the two schools of the treatment group (Stage 2) in this study, the language of learning and teaching in the schools (in the experimental group) on the West Rand was either English or Setswana. Thus, the teacher in the Setswana school could still translate into other languages but the Coloured bilingual teacher who spoke English and Afrikaans could speak only a few words in some African languages (Erling, Adinolfi & Hultgren, 2017).

Chomsky's view of language development posits that the ability to acquire language is biologically linked to age (Love, 1990). His language acquisition hypothesis postulates that there is a period of growth from early childhood to adolescence in which full native competence is possible when learning a language. In a similar vein, Ormrod (2006, p. 21) postulates that there are sensitive and critical periods for exposing humans to different abilities or characteristics. For example, for the 'three Rs' in early childhood development, there is no critical period for reading but there is a sensitive period for children to learn a language more easily, namely when younger than in adolescence or adulthood. Thus, language input plays a crucial role during the first year of life. Ellie Baker (2019) posits that children between the ages of 18 months and 5 years, learn up to 10 new words every day. Furthermore, researchers differ about time frames for a critical period of language. The hypothesis states that the first few years of life constitute the time during which language develops readily and after which, sometimes between the age of five and puberty, language acquisition is much more difficult and ultimately less successful. Moreover, several studies support the hypothesis that the critical period of phonology (CHP) or the critical period hypothesis is from 6 months until the 12th month of infancy, according to Ruben (1999). Data indicate that the sensitive periods for syntax run until the fourth year of life and, for semantics, until the 15th or 16th year of life (Ruben, 1999). Thus, the most sensitive period of acquisition (still regarded as very important) and development of language is the early childhood stage, and at around 17 years of age the sensitive period for language acquisition ends.

Some recent research findings indicate that the most effective period for the acquisition of a second language (L2) is during the age range of late childhood to late adolescence (Baker, 2019).

Baker is a French and Spanish teacher who teaches classes to young children and even babies, and contends that schools are focusing on qualifications rather than the skills needed for life, and that language is such a skill. Furthermore, there is an ongoing debate about whether teaching learners in the twelve home languages of South Africa will yield better results or not. Thus, Prof. Kakoma Luneta and colleagues have been to trying to find solutions to address this matter, particularly regarding the teaching mathematics in early school classes to improve the currently unsatisfactory mathematical skills of learners.

Luneta states that multiple mathematical classrooms, where three languages are spoken, could enhance learner understanding, change attitudes towards mathematics, and increase success (USAF, 2023). Moreover, in making a case for multilingual classrooms, Luneta and Legesse (2023) explained that English is usually the LOLT in public schools (Donald, Lazarus, & Lolwana, 2006; Luneta, 2018). There are many varying studies and outcomes regarding the benefits of multilingualism in teaching. Moreover, Luneta maintains that classrooms that embrace multiple languages enable ‘code-switching’ which refers to a process of alternating from one language to another in one conversation (also see Albertyn & Guzula, 2020). Hence this would encourage active learning of an alternative language while keeping the learner grounded in his home language. Luneta elaborated on this by adding that learners who are allowed to switch codes in class, and monitored by teachers, tend to express their understanding of the subject matter better to teachers and to their peers. In practice, after Grade 3, only English and none of the other official languages feature, and from Grade 4, English currently takes over as the sole medium of instruction in most schools. It is therefore expected from teachers to possess a deep understanding of both mathematics and the language context in terms of which the tuition is presented. This helps to ensure that after a few years learners become more fluent in English and fare better in the PIRLS assessment (Le Cordeur, 2023, July 31).

On a cognitive level, English is regarded as a very difficult language, while Afrikaans can be viewed as an easier language to learn (Sternberg & Sternberg, 2012), because English has complex grammar rules as well as many pronunciation variations, and properly mastering English requires a vast vocabulary (Erling et al., 2017). English grammar is riddled with exceptions and irregularities, thus rendering it difficult to master, learning English also depends on what the new language will be used for; for example, if a student attends classes at a tertiary facility, a good understanding of English and academic writing ability is needed in South Africa and worldwide. Both speaking a language and writing a document or essay are difficult cognitive processes. Among some of the challenges that people face with any of the African languages is a lack of information in African languages online; there is a perceived lack of resources; implementation of such languages is not monitored in universities; and there is also the problem that parents have displayed some resistance to multilingualism (Suryanto & Sari, 2021). The former model C and independent schools teach in English or in Afrikaans, but English is being used for the majority of learners in South Africa.

3.6.3 Decline in Participation in Mathematics and Science in South Africa

A decline in participation in mathematics and science in South Africa and poor mathematical skills or knowledge, and numeracy in South Africa and other countries abroad have been pointed out by various researchers, for example Luneta and Giannakopoulus (2016).

During the last decade, the unsatisfactory achievements in mathematics by learners in various countries worldwide, to name a few, United States of America, Europe, Spain and South Africa, were reported and discussed by researchers and politicians in the United States (Hanushek & Woessmann, 2012); Europe (Ferro, 2014; Trinchero, 2013) and South Africa (Rosholm, Gumede, &

Mikkelsen, 2017). According to *The Conversation* (1986, as cited by Suri, 2023) one of the problems in America in 1986 was that too few students were devoted to the study of mathematics. Nearly 40 years later, the problem has still not been solved, and may be even worse. In fact, after the Covid-19 pandemic, only 26% of the students were proficient in mathematics, yet approximately 30,600 jobs requiring mathematics are expected to open up per year owing to growth and replacement needs. Shortages will also arise in several other areas, since mathematics is the gateway to many STEM fields, namely science, technology, engineering, and mathematics. There is also evidence of school children and students struggling to master mathematics because it requires discipline and perseverance from learners. Thus, there is a call for colleges to deliver better prepared teachers with a more cumulative approach to succeed.

Furthermore, the pandemic disproportionately affected racially and economically disadvantaged groups during the lockdowns. These groups had less access to the Internet and quiet studying spaces than their peers had, but such Internet access is an important component of learning at home, and a working Wi Fi system and secure places to study are key aspects in the battle to improve the language, science, mathematical learning of pupils in schools. This could also positively contribute to learning because in 2017, according to Suri (2023) 58% of the United States of American adults enjoyed their school mathematics classes where Internet is widely available to learners.

Ormrod (2006, p.21) postulates that there are sensitive and critical periods for exposing humans to different aspects of learning or subjects. For example, for mathematics, according to Namukasa and Aryee (2021), the sensitive developmental period for learning mathematical concepts is between the age of four and six years. Maynier (2023, May 23), a politician in Cape Town, holds that South Africa does not face only a literacy problem, it also faces a numeracy crisis, one that has been amplified by the Covid-19 pandemic and associated closures. There is also a decline in mathematics and science in South Africa. Many schools in South Africa no longer offer science, for which mathematics is a prerequisite subject, and some schools offer only mathematics literacy which mainly depends on the ability to read well and to do basic calculations (Le Cordeur, 2020). Only the Western Cape undertakes annual systemic testing. This testing enabled them to track the impact of lost teaching and learning time during the pandemic, which has reversed gains made over the past decade in both language and mathematical scores. However, many of the Grade 3, Grade 6, and Grade 9 learners are struggling to achieve the basic pass score for mathematics and reading. Maynier (2023, September 18) maintains that a massive financial injection was recently granted to the 'Back On Track programme' in the Western province, with the aim to reverse learning losses in South Africa with extra resources and training in the Foundation Phase, and for the grades 4, 7, 8, 10 and 12 teachers.

As mentioned earlier, there is an ongoing debate about whether teaching learners in twelve home languages would yield better results or not. In the light of this, Prof. Luneta and colleagues in Gauteng argues that it is important to address this matter when teaching mathematics in class to improve the currently unsatisfactory mathematical skills of learners. Luneta maintains that multiple mathematical classrooms could enhance learner understanding; change their attitudes towards mathematics; and increase success (Erling et al. 2017). Moreover, in making a case for multilingual classrooms, Luneta summarised the key findings of existing studies.

In an investigation into the levels of school readiness of young learners (Janse van Rensburg, 2015), the common factor shared by all the schools is the low level of training that their teachers had received. Thus, Luneta (2018) opines that there are various reasons for this low level of teaching. The requirements for the entry levels of student teachers at university are lower than those for other students studying different degrees; for example, student teachers require only 60% for mathematics for their matriculation examinations. Student teachers require 'relearning' in mathematics, particularly geometry, according to Prof. Luneta, and not simply a background in remedial teaching due to poor mathematical performances on the Van Hiele Model of Geometric Thinking (Luneta & Legesse, 2023; Ohiri, 2023). Lastly, the teacher absenteeism rate is high, as stated earlier. Thus, the training level may be arguably regarded as key to the attainment of school and learning readiness of Grade R learners (Janse van Rensburg, 2015). Bruwer (2018) maintains that teachers in the Foundation Phase must be supported in various ways and dedicated a thesis to establishing ways to support teachers effectively. Furthermore, in the United States of America, a study of related literature shows that well-trained teachers follow a Reggio Emilia approach to education based on knowledge about how children learn and develop, that is, children develop best in a physically and emotionally safe environment where their basic physical and emotional needs are met (Marais & Meier, 2008; Janse van Rensburg, 2015; Erikson, 1972).

3.6.4 Lack of Critical Thinking Skills and Problem Solving in School Learners

There is a lack of critical thinking skills and problem-solving skills among school learners and South African citizens; for example, poor children and adults often fall prey to crime and/or human trafficking (Chaplin, 2007; Friedman, 2017). Young children gain knowledge mostly from parents or when in school; therefore, they will not be able to display critical thinking yet, but children aged 6 to 12 years develop the ability to think in concrete ways. Cognitive thinking in children, however, begins at about age two, and even at this stage when questions are asked about topics combined with a discussion, it will stimulate further thinking (Janse van Rensburg, 2015). Also, when young children exhibit incorrect thinking or wrong answers to topics, this indicates to the teacher or parent which learning areas or thinking skills require attention. The two main obstacles to critical thinking are assumptions and biases (Friedman, 2017). But apart from this there are a variety of reasons for a lack of critical thinking skills: thinking barriers such as egocentric thinking, groupthink, a lack of practising the basic principles of critical thinking, social conditioning, a perceived inability to critically view and argue about a topic or incident, arrogance, a stubborn nature, holding a distorted view of the truth, experiencing fear of the consequences of thinking, past experiences, and time constraints. When children experience barriers to the critical thinking process, this could seriously harm their ability to move forward. Lastly, Bourgois (2015) explains that it is known that teachers who work at no-fee schools in poverty-stricken areas and who stem from similar poverty-stricken areas, could also be part of the problem due to old or rigid problem-solving methods or habits that consequently sustain poverty.

3.7 Transfer Between Domains

3.7.1 Chess and Intelligence

When a chess tutor or a teacher presents new material or work to learners, it must be carried out in depth and information must be assembled in a meaningful, age-appropriate manner by relating it to the pre-existing knowledge of the learners (see Section 2.1.2). The latter aspect appears to be important in order to facilitate transfer or the 'carry over' of knowledge (De Corte, 2003: Gobet 2016; Gobet & Jansen, 2005; Perkins & Salomon, 1994). There are different types of transfer, namely far, positive, and negative transfer (Sternberg & Sternberg, 2012, p. 462).

Certain researchers believe that achieving an understanding of the cognitive and computational processes associated with a complex domain such as chess and an analysis of expertise in the domain will shed more light onto the mechanisms of the mind. Hence, chess has been called the drosophila of both cognitive psychology and artificial intelligence (Ensmenger, 2011, p. 1). It is also thought that such research may reveal some ideas for developing intelligent machines.

This ’transfer learning’ or ‘transfer of knowledge and skills’ is a widely researched topic in studies of expertise with several attendant issues (Gobet & Campitelli, 2006; 2007; Gobet, & Sala, 2019; Gobet & Sala, 2023; Section 2.4.2). One issue is whether attaining expertise in a particular domain is associated with a generally more efficient method of processing information which would then be reflected in enhanced abilities to process information in visual perception, working memory, and problem-solving abilities by experts in relation to novices. This issue was dealt with in the previous chapter. A more fundamental issue is whether attaining expertise in a particular domain such as chess would facilitate learning and foster the achievement of high levels of performance in other domains such as physics and mathematics. Hence, the issue is whether there is some transfer of expertise from one domain to another. The transfer of knowledge or learning across domains is very important in learning and, in chess, an important research question is whether there is any positive carry over effects to other disciplines that are causally related to learning and playing chess (Gobet, 2016; 2017).

Bilalić et al. (2007; 2008) conducted a study on children who had just begun to learn chess with the aim to establish a plan for their development over a period and to investigate the long-term effects of their exposure to chess. However, for the most part, relatively short correlational research has addressed this topic with mostly ambiguous findings, as discussed below.

One aspect associated with the belief of transfer that has evoked considerable attention relates to the question whether there is a causal link between expertise and general intelligence. This aspect is of particular interest pertaining to the game of chess because it seems as if there is a fairly pervasive perception among the general public that good chess players are smart people and that a high level of intelligence (i.e., high IQ) is needed to play very good chess (also see Grabner, 2014; Islam, Lee, & Nicholas, 2019; Jankovic & Novak, 2019). There is some support for the belief that chess players constitute an elite class. Thus, according to Grabner (2014), 78% of the World Chess Federation's (FIDE) chess players in the United States of America were university graduates in 2013, they were academically better qualified than people who have never played chess, and they received higher incomes than non-chess players. Levitt (1997) postulates that different levels of expertise in chess can be mapped against IQ levels in countries, which is based on statistical distributions. Moreover, Levitt proposes that the probability of achieving a grandmaster norm in a given country is equivalent to having an IQ of above 160 and derives the Levitt equation in support of this postulate.

On the other hand, Ericsson (1988) argues that expertise is gradually acquired through deliberate practice and the acquisition of domain-specific knowledge structures (Ericsson, 2007; 2017). Ultimately, there are not enough grounds to believe that Levitt's simple distributional argument resolves the intricate and fundamentally unclear relationship between chess Elo rating (1978) and the intelligence necessary to achieve it, as there are insufficient data relating to the measurements, and there are also nuisance variables that compromise the findings (Bilalić et al. 2007). Thus Bilalić, Gobet, and McLeod (2008) argue that there is little evidence to support the widespread conviction that chess players are smart and that many studies that have investigated this topic suffer from methodological problems. For example, the amount of practice and the years of chess experience are not taken into account in some studies, and the researchers tend to focus on only one variable, namely intelligence, while ignoring other variables that may impact on the acquisition of skill in chess.

Other researchers contend that some threshold level of intelligence is required to attain expertise in chess. Grabner (2014) investigated the role that intelligence plays in the acquisition of chess expertise by conducting a meta-analysis of several studies. These results confirm that expert chess players do indeed possess above-average intelligence, that their playing strength in chess correlates with their individual levels of intelligence, and that they display significantly higher intelligence than the controls. He thus concludes that these results clearly demonstrate that "expert chess play does not stand in isolation from intelligence" (Grabner, 2014, p. 310).

Furthermore, Howard (2009) performed an analysis of a longitudinal data set of a large group of chess players (*N*=3471), with the aim to investigate whether there are significant individual differences between expert chess players and where these differences cannot be entirely attributed to differences in the amount of chess practice devoted to the game. Some players reached expert levels of performance more quickly than others did, and also by playing fewer games than others had played. Moreover, a factor analysis of various variables in the data set revealed evidence of an underlying natural talent factor that seemed to affect the performance level that was ultimately obtained. In the current state of research on the relationship between chess, cognition, and intelligence, it appears that there is some consensus that sustained practice is sufficient for expertise in chess but there is still no real clarity about the role that inborn abilities and environmental factors play in the acquisition of expertise in complex domains such as chess.

3.7.2 Transfer of Skills.

According to Sala and Gobet (2017), researchers take it for granted that efforts to promote chess in schools will transfer to other domains, and in a meta-analysis, they critically reviewed the putative benefits of chess instruction to academic and cognitive skills. Schools aim to teach general strategies, and an activity is taught in the hope that the relevant skills underlying that activity that can be usable in other domains will be transferred. Transfer of skills is either a tacit or implicit assumption and the specific aim of nearly every educational programme (Donovan & Radosevich, 1999; Perkins & Salomon, 1994; see Sections 1.4.2; 1.5; 6.3.3; 6.6).

The game of chess is an activity that has been used in this manner (Campitelli et al., 2014; Gobet, 2016; Gobet & Sala, 2023). Thus, Sala and Gobet (2017) explain that the aim of chess as an instructional tool is that it will allow children to transmit the knowledge and understanding that they have acquired in chess when they are exposed to a new programme or subject matter.

Transfer is an important matter in both theory and practice (Mestre, 2005), but one should bear in mind that it has been proposed that transfer is a function of the extent to which two domains share common features (Peterson, 2002; Thorndike & Woodworth, 1901) and cognitive elements (Anderson, 1990; 1996). Sala and Gobet (2017) explain that near transfer is often observed, as mostly expected, and that transfer may occur in closely related domains of knowledge, but that it is only partial between subspecialities of expertise such as cardiology and neurology (Rikers, Boshuizen, & Schmidt, 2002). Certain researchers even argue that far transfer is difficult or non-existent (Donovan & Radosevich, 1999; Gobet & Sala, 2023). They include research on teaching the computer language, LOGO in order to improve the thinking skills of children (also see De Corte 2003; Gurtner, Cattaneo, Mauroux, & Motto, 2011). Thus, it seems that the higher the skill, the more specific the features of a domain will be and the lower the chances and the likelihood that there will be transfer (Ericsson & Lehmann, 1996). This is the case because a large number of domain-specific perceptual chunks of knowledge must be acquired for transfer to occur (Gobet, 2011; Gobet, 2016). Again, there are exceptions and some individuals have excelled in several different domains.

3.7.2.1 Transfer to Mathematics. Many researchers world-wide believe that chess playing can remedy poor education, and this is also the case in South Africa (Luneta, 2018; Ferro, 2014; Novak & Jankovic, 2019). Trinchero and Sala, (2016) explain why the latter is a concern. The current market requires more graduates in the (STEM) subjects than graduates in the humanities.

Moreover, STEM-related jobs require highly skilled employees, which is of concern in light of the high unemployment rate and academic dropout percentage in South Africa (Fraser, 2023). The low mathematical ability of learners is a serious impediment to the satisfaction of job market demand, both qualitatively (level of mathematical competences in graduates), and quantitatively (the number of graduates in STEM subjects).

As already mentioned, Prof. Kakoma Luneta (Luneta & Legesse, 2023) who is a former mathematics teacher, reports that in a study of128 student-teachers in South Africa, it emerged that the mathematical skills of Foundation phase teachers were limited with particular reference to their knowledge of geometry. According to the Van Hiele levels of the geometric thought model, the prospective teachers were operating on level 1 only while it was expected that Grade 12 learners must operate on levels 3 and 4, the levels of the learners that the teachers will have to teach after they have completed their studies. As a result, plans were made to address this issue with the goal of not just providing remedial teaching but rather for teaching students to 'relearn' (Luneta & Legesse, 2023; Rosholm, et al., 2017).

Dlamini and Maphalala (2021) maintain that some teachers who incorporated chess principles or concepts in mathematics classes in schools as part of a chess initiative in certain areas in South Africa, felt that they were cognitively and administratively overloaded. Some of these teacher-participants indicated that they would have preferred a monetary reward for any additional tasks or responsibilities during and/or after school hours, despite the fact that there was some improvement in the mathematical skills of the learners and that most of the teachers welcomed the implementation of a chess initiative in their respective schools.

Several overseas and South African studies have reported positive effects of chess instruction on mathematical problem-solving or numerical thinking. Unfortunately, only a few studies are generally deemed to have made use of sound research methods (e.g., Frank & D'Hondt, 1979; Fried & Ginsburg, n.d.; Scholz et al., 2008). Therefore, no valid conclusions can be drawn regarding the relationship between chess and mathematics. However, Isabella (n.d.) reviewed a large number of studies which have demonstrated a positive effect of chess on number problems in the classroom. They theorise that the benefit of chess on mathematical problem solving in classrooms may emerge from the fact that chess helps learners to deal with symbols because, in chess, symbols such as chess notation are concretely linked to visuospatial patterns on a chess board, whereas mathematics involves only 'pure symbolic manipulation' (Isabella, n.d., p. 97).

In similar vein, Bilalić et al. (2007; 2008) maintain that chess experts develop a sensitivity to patterns of meaningful information that are not the same for non-experts. This is also applicable to mathematics (Nagavalli, 2015). There are spatial schemas that serve to represent the segmented perceptual field (learning how to see); therefore, teachers can provide learners with opportunities that specifically enhance their abilities to recognise meaningful patterns of information (e.g., Bransford, Franks, Vye, & Sherwood, 1989). The accumulated knowledge of experts is well organised around core concepts or big ideas that guide thinking about their domains while novices focus on surfaces in contrast with experts who focus on big ideas or principles. In mathematics, experts with more conceptual chunks of knowledge than novices try to understand the problem first before trying to solve it whereas novices often tackle the problem before properly understanding it. Experts possess a vast repertoire of knowledge that is relevant to their domain or discipline while only a subset of the knowledge is relevant to any particular problem.

Wells (2012) elaborates on this by discussing a number of ways in which games such as chess influence mathematical thinking. According to Wells, as a mathematician as well as a chess player, one must observe a problem and consider various approaches or moves to solve it.

Furthermore. while both the mathematician and the chess player must identify possibilities, the mathematician also “studies objects like the pieces in an abstract game of chess” (Wells, 2012, p. 3). Thus, after conducting an experimental study with the aim to investigate whether training in chess could improve the PISA mathematical scores of learners and whether a relation exists between chess and mathematics in Italian primary schools, Trinchero (2013) found a positive gain in the mathematical achievement by the chess treatment group. This was also positively correlated with the duration of the chess course (r = 0.139, p = 0.007, significant). Some researchers like Barrett and Fish (2011), Ferro (2014), Kazemi et al. (2012) and Sala, Gorini, & Pravettoni (2015) investigated the relationship between chess playing and mathematics in different ways.

In 2014, the University of Johannesburg undertook one of the largest studies in South Africa (Luneta & Giannakopoulos, 2016) with the aim of investigating the relationship between chess playing and mathematics in an exploratory study conducted in the South African context. A total of 10 teachers and approximately 1800 learners were involved in schools in South Africa and one school in Uganda. Grades 1 to 3 learner-participants were involved in this study and the participants in the treatment group received chess instruction during school hours. The results in the study indicated that there is a correlation between chess playing and the learning of mathematics (also see Nicotera & Stuit, 2014). This suggests that the uniqueness of the South African situation which lies between a First and Third World country could offer some new insights into the role that chess plays in the teaching and learning of mathematics. Numerous other studies originated from this sample, for example, studies conducted by Dlamini and Maphalala (2021) regarding the perceptions of teachers after their involvement in incorporating chess knowledge in mathematical classes and the views of relevant stakeholders in the study undertaken by Luneta & Giannakopoulos (2016).

Trinchero and Sala (2016) investigated whether a specific type of chess training does improve mathematical skills of children and they uphold the notion that teaching heuristics can be an effective means to promote the transfer of learning. In their study, 931 children from primary schools were recruited and assigned to either two treatment groups attending chess lessons or a control group, and after this the learner-participants were tested on their mathematical problem-solving abilities. Different teaching methods were used by the chess instructors; thus, one trainer taught the learners heuristics to solve chess problems, and another trainer in another treatment group did not teach any specific problem-solving heuristics to the participants. When the results of the study were analysed, the former group outperformed the other two groups. These results therefore support the hypothesis that a specific type of chess training does improve the mathematical skills of children, and suggest that teaching general heuristics can be an effective way to promote transfer of learning (Ferro, 2014; Trinchero & Sala, 2016).

Trinchero and Sala (2016) report on the state of the literature in general. They maintain that chess teaching was proposed as an educational tool to enhance the cognitive and academic abilities of the children. The latter was based on extensive empirical evidence suggesting that chess players tend to be more intelligent than the general population. Thus, several studies have been carried out to demonstrate or to refute the benefits of chess playing, especially pertaining to the mathematical abilities of children (Trinchero & Sala, 2016, p. 656). Moreover, chess instruction seems to effectively boost the mathematical abilities of children but some doubt remains regarding the goodness of such a practice. In fact, many studies lack a proper experimental design or randomisation, according to Gobet and Campitelli (2006; 2007).

In a meta-analysis, Sala and Gobet (2017) investigated whether chess instruction would improve mathematical problem-solving. There was a significant effect in favour of chess playing groups. However, the meta-analysis also showed that most of the studies used a poor design, often with a lack of active controls. Thus, Sala and Gobet (2017) conducted two experiments that used a three-group design by including both an active and a passive group with the focus on mathematical ability. In the first experiment, a group (*N*=233) of third and fourth graders were taught chess for 25 hours after which they were tested on mathematical problem solving. Thereafter, they filled in a questionnaire to assess their metacognitive skills (Wang et al., 2003). The chess playing group was compared to an active control group who played checkers and a passive control group (see Section 6.4.5). The three groups showed no statistically significant difference in mathematical problem solving or metacognitive abilities in the post-test. The second experiment (*N*=52) broadly used a similar design but the game of checkers was replaced by the Oriental game of Go in the active control group. While the chess-treated group and the passive control group slightly outperformed the active control group with mathematical problem solving, the differences were not statistically significant. Furthermore, no differences were found with respect to metacognitive ability. Hence, these results suggest that the effects, if any, of chess instruction are modest when rigorously tested. These researchers argue that such interventions should not replace the traditional curriculum in mathematics, but Gobet and Sala (2023) also suggest that more boardgames should be included in future research investigations.

In the same meta-analysis study, Sala and Gobet (2017) also explored working memory (WM) training in young developing children. The results suggest that WM training is ineffective in enhancing the cognitive and academic skills of young developing children and that when positive effects are observed, they are modest at best. Thus, this finding falls in line with other types of training that state that far transfer rarely occurs and that its effects are minimal.

Sala and Gobet (2017) report that mathematics is viewed as a prerequisite for gaining jobs in STEM discipline, which underpins the technical future of humans. Thus, there are different proficiency levels between countries, which is of great concern. Most of the studies have focused on the chess player and the putative benefits of chess instruction in mathematics. However, Sala and Gobet (2016; 2020) evaluated the effect of chess instruction on cognitive and academic skills, and found that chess does appear to enhance the achievement of primary and middle school learners in mathematics and their overall cognitive ability. Nevertheless, despite the promising results, the Sala and Gobet (2017) meta-analysis points out that these findings should be viewed critically as this are some problematic research results, especially in relation to mathematics, and also a lack of immediate post-tests in some studies which does not allow any direct comparison with previous studies. The focus falls on short-term benefits as in most of the research studies, and one cannot rule out the role that placebo effects may play.

Furthermore, music requires more instructional time than chess playing, but there is also evidence of failed far transfer in music (Gobet, 2016; Sala, & Gobet, 2017). Thus, researchers suggest that the validation of chess as an educational tool must undergo further research. Although the final verdict regarding the effect of chess and mathematics is still uncertain, some studies suggest that a positive relationship does exist between these domains, and there are also some intuitive connections that suggest that the issue may need further research. For example, children must acquire an understanding and visualising of spatial relations in chess, where spatial visualisation is a process that refers firstly to the ability of one to orient oneself to surroundings but it also relates to the ability to manipulate images of objects mentally (see Section 2.4.2). Fine (1965, pp. 364-369) maintains that spatial visualisation is important in chess playing, because players are not allowed to move or touch chess pieces physically while thinking and selecting the next move and, in this manner, construct an image of the effect of the move on the configuration of pieces on the board. This understanding and visualisation of spatial relations could well be significant for the subsequent development of mathematical abilities such as topology or geometry where spatial visualisation is also important (Sternberg & Sternberg 2012).

3.7.3 Transfer to Reading and Verbal Aptitudes.

Reading is an important skill. Thus, in the following studies carried out by several researchers (Frank & D'Hondt, 1979; Liptrap, 1997; Margulies, 1993), there is evidence of children and adults who report improvements in reading and verbal aptitudes after exposure to prolonged chess practice (Eysenck & Keane, 2020, p. 453). Smith and Cage (2000) contend that more instructional time is needed when domains such as chess and reading differ from one another. While a minimum of 25 hours of instruction is required in the chess domain, 30 hours of exposure to treatment is needed to facilitate transfer from chess to verbal aptitudes or reading. The explanation for an improvement in reading abilities may be due to the notion that chess can enhance children's self-esteem enabling learners with a low reading ability to become more self-confident, gather more courage and improve. However, this may just generate a low transfer effect that is not specific to chess. Another explanation could be that chess requires players to visualise concepts and piece movements together which allows for better visualisation or interpretative skills when reading (Smith & Cage, 2000).

However, Gobet (2011) explains that the results of these studies (Christiaen & Verhofstadt-Denève, 1981; Frank & D'Hondt, 1979; Fried & Ginsburg, n.d.) only weakly support the hypothesis of transfer from chess instruction to other domains with little evidence of an increase in school performance, intelligence, and creativity. The interpretation offered by Gobet (2011) agrees with previous research studies known in psychology as 'transfer of knowledge or skills', for instance, that transfer is limited and that chess playing may be beneficial in the early stages of acquiring chess skill. Although it appears as if transfer of knowledge decreases in the later stages of improving skills after prolonged exposure to chess practice, as well as specificity of the information is required. Chess practice also enhances interest in school matter in underprivileged areas as well as in bored learners and concentration skills improve, while children also learn to lose as a result of the transfer of skills. A longitudinal, related-measures design of Bilalić et al. (2007) included the variables of chess skill, namely intelligence, motivation, amount of practice, and personality. Thus, certain researchers (Campitelli & Gobet, 2008) argue that other variables also play a role in chess expertise such as season of birth, handedness, and general cognitive abilities. These variables as well as 'starting to play chess seriously at an early age' are considered to be important in the first stages of a chess career and in the quest to reach high levels of expertise (Section 2.6).

3.8 Chess as an Educational Instrument

Chess is a cognitively demanding game which involves a number of cognitive skills, namely attention, concentration, memory, information, processing, logical reasoning, problem solving, and strategic decision making (Jankovic & Novak, 2019; Rosholm, et al., 2017).

3.8.1 Low-Risk, Low-Cost and Effective, Link Between Chess and Intelligence

According to Scott (2019), chess is a low-risk and low-cost route to creativity, cross-curricular learning, and attainment. Furthermore, Trinchero and Sala (2016) claim that chess is an effective tool to foster mathematical skills of children. Thus, the European and Spanish parliaments also support chess as an educational tool. There is also support for chess playing in South Africa, especially when the Department of Basic Education granted permission and assisted with the large-scale (longitudinal) study undertaken by Prof. Luneta and Doctor Giannakopoulos in 2014 (2016) of University of Johannesburg. Hence, many schools in South Africa and in the world offer compulsory chess in schools, or as an additional subject during school hours, or in chess clubs after school. Many researchers (Elo, 1978; Gobet & Campitelli, 2007; Ogneva, 2017) have investigated the optimal age for exposing children to chess playing. There is some research that supports the link between chess skill and intelligence as represented on an intelligence measure in children but not in adults (Frydman & Lynn, 1992; Waters et al. 2002). Furthermore, Sections 3.7; and 3.8.2 contains further information about when to expose learners to chess playing when regarded as an educational tool.

3.8.2 Educational Benefits

McDonald (2010, p. 3) notes various educational benefits that chess could potentially offer to children as identified in various studies, for example, fostering problem-solving abilities by giving immediate feedback on problem solving strategies, aiding the development of mental alertness, rewards, creating a positive attitude towards learning, and participating in competitions (Jankovic & Novak, 2019). Before using chess as an instrumental tool, it is important to bear in mind that, in South Africa, young learners normally learn pawn movements first even though a pawn is considered to be the trickiest of all the chess pieces. Ogneva (2017) explains that, initially, pawn movement can be very difficult for small Grade R children to understand and memorise. Moreover, a pawn does not only move forward but diagonally, at an angle, which is difficult for young children to view because they must still learn to converge and diverge with their eyes (Ogneva, 2017). Thus, the movements of rooks are viewed as being much easier for young chess beginners to learn.

Furthermore, pawns are the only chess pieces that may not move backwards and they are also involved in a difficult to explain special move, namely *en passant*. Thus, pawns move forward to promote to a queen or chess piece of choice.

3.8.3 Requirements for the Ideal Experiment and Suggestions

One should bear in mind that a common pattern in the research literature is that peer reviewed results in research have greater effect sizes and that the studies with good results are more likely to be published (also see Hunter & Schmidt, 2004). However, Gobet and Campitelli (2006) explain that while some researchers make strong claims about the alleged educational benefits, there is not much valid research to support the mentioned claim mainly because it is difficult to separate the effects of transfer or transfer of knowledge from normal learning in individuals.

Thus, in the quest for 'the ideal experiment' in research studies, Gobet and Campitelli (2006) propose that research into the cognitive and scholastic benefits of chess need to follow the requirements of the ideal experiment. The latter would require a correct design in an investigation, where it is necessary to take into account the application of randomisation. Children in the experimental group may be affected by a placebo effect (improving due to attention given to them rather than due to chess instructions), which will not happen to the control group. Furthermore, researchers must take note of mechanisms that could produce placebo effects such as the motivation of the instructor, the state of motivation induced by a novel activity, and educational expectations (Gobet & Campitelli, 2006; 2007). Since a lack of control of effects and variables, namely dependent and moderator variables, these studies cannot evaluate the specific skills.

It is better to identify the specific characteristics of chess that may improve abilities of children and which abilities they foster. Therefore, one cognitive and one academic variable could be included in an experimental design so that chess can exert a positive influence on both academic and cognitive improvements, even if it is slight. In view of the aforesaid, further research is needed (Sala & Gobet, 2016; 2017; see Sections 6.3; 6.4; 6.7).

3.8.4 More Research Needed in Future

Moreover, it will be very important to consider problems associated with the direction of causation as well as the correlation-causation issue in the data analysis. In 2014, Bart presented a critical review of studies that investigated the educational benefits of chess. They explain that the current state of the literature is still inconclusive pertaining to the latter and concludes that although some studies show that chess could have a "salutatory cognitive and educational effect" further research is needed to prove such a conclusion in a scientifically valid manner (Bart, 2014, August, pp.1-3). Bart also believes that further research is needed because converging evidence may eventually help to settle the matter by means of systematic reviews and meta-analyses of the existing data.

3.8.4.1 The Value of the Perceptions of Learners. Chitiyo, Ablakwa, Akenson, Besnoy, Davis, Lastres, Littrell and Zagumny (2021) maintain that the perceptions of learners, 'the students' voices', of the benefits of scholastic chess instruction, even if transfer of benefits are rare, are also important when evaluating an educational tool. Positive feedback was provided by many school learners while they were involved in 'in-school' chess playing or classes given by various chess initiatives in South Africa. Furthermore, in a report compiled by Nicotera and Stuit (2014), a systematic review of literature was included. The aim of this review was to examine the degree to which existing empirical evidence supports the theory that participation in chess programmes, whether designed as 'in-school' (Chess-in-Schools/CIS) or 'after-school' (chess) programmes, resulted in improved academic cognitive and/or behavioural outcomes for typically developing children. Altogether 24 studies met a set of pre-determined criteria for eligibility and were included in the analysis. The literature review found that both 'after-school' chess programmes and 'in-school' chess interventions exerted a positive and statistically significant impact on mathematical outcomes.

While the two primary outcomes of studies utilised rigorous research design methods, the results should be interpreted cautiously given the small number of eligible studies that the pooled results encompass, namely two high quality after-school studies and six high quality in-school studies. The after-school studies examined competitive chess clubs and provided very little detail about how the programmes were implemented. The CIS studies examined scholastic chess programmes that use chess as a springboard to work on cognitive and academic skills that are critical to learner performance in school. Chess programmes were included in the weekly academic schedules of the learners and instruction during the school day led to higher school attendance rates of learners and lower attrition. The programme was administered for an extended period, the length of which was not disclosed, and during the classes in the intervention, mathematical concepts were connected to the chess curriculum. Little detail about the implementation of the chess programmes was provided.

While chess can be taught in many ways by many different people, chess experts are mostly not good trainers (Malamed, 2009; Persky & Robinson, 2017). Therefore, there is a need for a specific prescribed curriculum, which is not ideal owing to individual needs and the different educational levels of the learners and chess players (Ogneva, 2017). Researchers noticed that children who were diagnosed with autism, were helped by these chess interventions of in-school or after-school programmes. Moreover, there were also higher school attendance rates by learners and lower attrition rates (DuCette, 2009). Lastly, a cross-sectional longitudinal study is needed; one that shows the benefits of chess instruction and controls for socio-economic status and other educational variables (DuCette, 2009, Nicotera & Stuit, 2014).

3.9 Concluding Remarks and an Outline of the Methodology

In this theoretical chapter, the socio-economic situation and the cognitive developmental issues in South Africa were described as a background to this current research investigation. In Stage 1, the former Model C school, homogenous regarding to language and culture, formed part of the 'well- functioning' schools in South Africa, and (teachers) required no comparison because the teachers were all qualified. In Stage 2, the three schools, in the control and experimental groups, in the different educational environments were compared with one another because they were not homogenous in language, culture, and qualifications. The transfer of knowledge gained in various domains while playing chess was discussed in this chapter. The methodology covering the research design, sample size, selection of participants, and the measuring instrument, to name a few topics, are all discussed in the next chapter.

Chapter 4

Research Methodology

The aim of this research is to investigate whether teaching young, pre-primary school children to play chess has a positive effect on the development of their cognitive abilities and scholastic performance. In this chapter the methodological approach associated with this research aim is set out, and in so doing the general research strategy, sampling process, and instruments are described that were used to execute the research. This study involves empirical research based on the standard quantitative research paradigm in Psychology. The research is situated in an overall research project involving two distinct stages of research, both of which are described and justified in this chapter.

4.1 Two stages of Research

In the first stage, instruction in chess as a treatment factor is investigated by comparing two groups, a control and an experimental group, in an otherwise relatively homogeneous school environment. In this part of the overarching research study, the intention was to establish whether exposure to chess learning has an effect on young children's cognitive and scholastic development in a context where socio-economic and other nuisance variables are kept mostly similar.

The second stage investigates the effect of chess on young pre-primary children's cognitive and scholastic development in developmental schools, and here school itself becomes a variable. In this second stage the children in some of the schools are exposed to chess learning but children in other schools do not receive any exposure to chess or chess playing.

As can be gleaned from the explanation above, the first stage functions as a precondition for continuing with the second stage of research, and there was therefore a specific timeline in conducting the two stages of the research process. This first stage of the research project is based on

Basson, (2015) and uses the data collected during that study. This part of the overall research project therefore involves data and research preceding the second stage of research. The research of Basson (2015) is presented again in this thesis because it serves as logical prelude to the second stage, but the data yielded by that study will be reanalysed with different software and techniques in this thesis. The presentation and analysis are therefore not just reproduced from the previous study.

The first stage is conducted to determine if learning chess has any effect on young children's intellectual development, and the second stage extends the research to determine if learning chess can also affect the cognitive and scholastic development of young children in developmental schools.

4.1.1 Stage 1: Learning Chess in a Former Model C School

The first stage involves a standard quasi-experimental design used to determine whether chess instruction has an effect on the intellectual abilities (i.e., the early cognitive and scholastic development) of young pre-primary school children in the South African educational context.

4.1.1.1 Research Design. A quasi-experimental design was selected for collecting and analysing data, partly because full control could not be exerted on all the nuisance variables, but mainly because a convenience rather than purely random sample was used (Field, 2018, pp. 19 - 21). The influence of chess instruction on the development of the intellectual abilities of the young children was explored using a 2X2 repeated measures analysis, with two groups who were analysed at two different time points.

The treatment or intervention variable is a categorical variable, because there were two different groups, a control group not receiving chess instruction, and an experimental group that was exposed to chess instruction. The dependent variable, or outcome variable, is 'intelligence' a continuous, interval scale variable measured on the Junior South African Intelligence Scales (JSAIS), and its different subscales (performance, verbal, numerical and global intelligence) (Field, 2018, pp. 9 – 11).

4.1.1.2 Sampling Process. The sampling procedure was conducted on a Grade R pre-school in Pretoria where the researcher worked as a chess instructor. The Grade R school environment was considered appropriate for investigating the effect of chess on cognitive development, due to the general plasticity of children's brains in this age group which makes them susceptible to environmental influences such as learning to play chess (Foxcroft & Roodt, 2005, p. 319). A sample of children were selected from this school, and they were all White, Afrikaans speaking and roughly similar in age (between 5 and 6 years old). Chess was offered as an additional activity to the learners, and parents could subscribe them to this supplementary game, therefore they formed part of a non-probability, convenience group. During a parents' meeting, parents were also asked to voluntarily consent for learners to take part in a control group. Please note that the name of the school is withheld in accordance with current ethical principles governing psychological research which requires researchers to ensure anonymity of both schools and participants (see Section 4.1.1.6).

The sample initially involved 64 Grade R participants. The experimental or chess group consisted of 19 boys and 15 girls (n=34), and none of these children could play chess, but they were taught to play at a basic level during the chess classes presented at the school by the researcher. The control group comprised 16 boys and 14 girls (n=30) and these children were not exposed to any chess instruction at school during the research period (40 weeks). Gender was not taken into consideration during sampling and this resulted in a slightly unbalanced design with uneven cells in the two groups, but this could not be prevented due to practical circumstances during sampling.

None of the children received any additional therapeutic or instructional interventions, but two children, one in each of the control and experimental groups received medication to improve their attention and concentration.

The participants selected for the research can be assumed to reasonably represent Grade R learners attending a model C, public school, in South Africa. The sample was furthermore homogeneous in terms of aspects such as language (Afrikaans was their home language), educational status, age, and culture, as the learner-participants were all in Grade R during the execution of the research.

4.1.1.3 The Procedure. A non-probability, convenience sampling process was used to form two subgroups consisting of learners receiving chess instruction (the experimental group) at school, and a control group of learners of the same age at the same school, but who did not receive any chess instruction classes.

The participants in the experimental group received chess instruction from the researcher who taught them the rules of the game and allowed them to play against one another on a weekly basis during chess classes at school. The experimental group received approximately 20 hours of chess instruction during the relevant year (40 weeks over 4 terms = 20 hours). Thus, time was regarded as an independent variable in this research study. It is, however, not known whether the participants in the control group received any chess instruction prior to the onset of this investigation or during the period of the investigation. It is also possible that these young children could have taught one another to play the game of chess, without anyone even knowing. This is a situation over which the researcher had no control.

Parents and legal guardians, willing to allow their children to participate, were asked to fill in a form to grant written consent to submit their children to the research study, and all the relevant biographical data about the participating children were collected and the necessary biographical data about the participants were also recorded in the response booklets and on the computer for processing and safe-keeping. In order to establish a baseline, the (pre) test was subsequently administered individually (this could take up to 90 minutes) to all the participants during the course of the first term.

The participants in the experimental group commenced with chess instruction in the beginning of the year after enrolling voluntarily. The intelligence levels of both groups were measured by a registered psychometrist who administered the JSAIS in January (at the first, time point) and then again during November and early December at the second time point.

In order to ensure that there is consistency in the administration and scoring of the test results, these were all carried out by the assessment practitioner. The raw points achieved by each participant were converted to scale points in order to enable comparison to the norms as well as to those of the other participants. The numerical data were entered in a spreadsheet (Microsoft Excel) and were then used for subsequent statistical analyses, as will be described in the next chapter.

4.1.1.4 How the Chess Instruction was Presented. The young children participating in the chess instruction did not have any real understanding of chess, and therefore had to be taught the basics of the game from scratch so that there was an acceptable foundation for further learning and improvement of their knowledge of the game (also see Bocchi et al., 2024; Ferguson, 1995; Kennedy, 1998; Waters et al., 2002). This instruction took place during group sessions on two weekday mornings, and the participants were divided into two groups to facilitate individual attention. Each lesson lasted half an hour, and during this time the children learned about the movement of the chess pieces and rules of the game. This went on for a period of about 9 to 10 weeks. The basic rules of the game chess and movements of the chess pieces were communicated to the children in accordance with Ericsson's (1988) suggestions for developing memory skills (see Section 2.1.5). For example, when introducing a new chess piece to the participants, they studied its movements in comparison to the other pieces and practiced moving it on the board. The instructor also made use of colourful pictures, employed storytelling as a technique to highlight crucial concepts and themes, and the children engaged in role-playing, created clapping movements for different chess pieces and made physical movements to show the movements of chess pieces. In accordance with Ericson's memory and learning guidelines, the participants were therefore offered sufficient practice (see Section 2.1.2).

To further bolster their learning and understanding of chess, the children revised what they had learned previously before each new lesson. This was done to facilitate the memory retention of the older knowledge. The children were also sometimes given small rewards (a sweet, or a star) as positive feedback if they performed better than expected. Following the foundation phase of the learning process, the participants practiced their skills at a more advanced level by learning about opening moves, how to position the chess pieces, and they also began to plan and reason about attacking and capturing the opponent's king (Peterson, 2002). However, it should be noted that this next phase of the game is far from easy for the typical Grade R, 1 and 2 learners. Throughout the duration of the chess teaching lessons, the instructor assisted the participants by providing positive feedback where possible, and by making suggestions to help them to improve their playing of the game and to increase their self-confidence in their own playing ability (Ormrod, 2006, pp. 41-42; Vygotsky, 1997).

4.1.1.5 Description of the Measuring Instrument. The Junior South African Individual Scales (JSAIS) is a psychometric instrument last revised in 1981, but still commonly used by psychometrists or psychologists for measuring intelligence in South Africa, after obtaining these tests from the test distributors (Mindmuzik Media, 2000). The JSAIS was initially developed for testing White, English or Afrikaans children but was later also standardised for use with Indian and Coloured children. It has not been extended to other culture-groups in South Africa, due to the availability of other individual intelligence tests, for example the Individual Scale for Northern Sotho speaking and/or Southern Sotho speaking learners, as well as for Zulu speaking learners (Mindmuzik Media, 2000; Madge, 1981a; Madge, 1981b; Madge, Van den Berg, & Robinson, 1985).

The JSAIS was designed to measure children's cognitive ability between the ages of 3 and 8 years of age. The full battery consists of 22 tests, but only 12 of these are typically used to measure the level of children's cognitive functioning. The scale yields information about General Intelligence (GIQ), and there are subscales indicating Verbal, Performance, and Numerical abilities (Madge, 1981a).

The Verbal Subscale provides a measure of a child's ability to understand and process verbal information and communicate learned knowledge via language.

The Performance Subscale is a reflection of a child's ability to manipulate objects and to navigate the world using visual-motor co-ordination, visual organizational ability and visual-perceptual skills.

The Numerical Subscale yields an indication of a child's level of numerical and quantitative understanding, and the attendant ability to count, reason with numerical information, and to use memory skills effectively.

In psychometric applications, the JSAIS is used to determine the overall measure of global intelligence and cognitive functioning of children, but it is also a useful tool to obtain diagnostic information about their level of school readiness (Theron, 2013; Van der Merwe, De Klerk &

Erasmus, 2022). Because the JSAIS provides information about a child's cognitive profile and levels of intelligence, it was deemed a suitable instrument for use in this research.

4.1.1.5.1 The reliability of the JSAIS. Based on the currently available research results, there is a general consensus that JSAIS still has satisfactory reliability, but only for the specific population for which it had been standardised:

Using the Kuder-Richardson Formula-8, the internal consistency of the 12 subtests composing the JSAIS were shown to vary from 0.67 to 0.97 for the age groups 3 to 5 and from 0.67 and 0.91 for the age group 6-7 (Madge, 1981a, pp. 55-58). An exception is the Picture association subtest for which no reliability values were given.

For the age group 3-7 years, the reliabilities of the composite GIQ scale varied between 0.96 to 0.97, suggesting that it constitutes a satisfactory measure of global intelligence (Van der Berg & Robinson, 1985, pp. 21-22).

With regard to the VIQ and PIQ scales, reliabilities are acceptable, ranging from 0.91 and 0.96 for the 3-7 age groups.

The reliabilities for the Numerical scale (or Num subscale) were slightly lower, but still acceptable, and varied between 0.87 and 0.89 for all the age groups.

The intercorrelations between the five scales GIQ, VIQ, PIQ and the Memory (Sub)scales vary between 0.59 to 0.91 (for ages 4 to 7 years old) and those of the Numerical subscale vary between 0.52 to 0.80 for the same age group. Madge (1981a, pp. 57 and 64) argues that these intercorrelations do reflect a substantial amount of common variance, but that they are low enough to suggest that the measurements yielded by the individual scales cannot readily be inferred from one another.

4.1.1.5.2 The Validity of the JSAIS. The JSAIS is a relatively old scale and where its reliability seems adequate, the validity of the instrument is more problematic. Different types of validity are relevant here such as content, construct, criterion-related validity, and predictive validity (see Field 2018, p. 15; Theron, 2013).

a) Content validity

The JSAIS has some face validity due to the inclusion of colourful object pictures familiar to children to illustrate the content descriptions in the booklet**.** Also, after a systematic content analysis of the scale, a panel of experts concluded that it does have content validity (Wolfaardt, as cited in Foxcroft & Roodt, 2005, p. 49).

b) Construct validity

Factor analysis was used to validate the scale and yielded satisfactory loadings of 0.3 or higher (0.3 to 0.77) on the unrotated first factor of all the individual subscales composing general intelligence. The scale therefore has acceptable construct validity (Madge, 1981a, p. 71-75). With a stricter cut-off point of 0.50, the subtests Form Board and Memory for Digits did not comply with the criteria needed for inclusion in the general intelligence battery, but they were still included for various other reasons.

c) Criterion-related or empirical validity

The JSAIS is generally accepted to have two types of criterion-related validity: predictive, and concurrent validity (Field, 2018, pp. 15 – 16). The instrument has predictive validity because it has been used successfully to predict future school achievement, and it is still widely used in South Africa by many psychometrists and psychologists (Theron, 2013). In this research the children were assessed twice on the JSAIS, and this provides some support for its concurrent validity, because all the results increased and none decreased during the time period, as one would expect to be the case during a Receptive Grade year (see Madge 1981a; 1981b). Furthermore, a translated version of the JSAIS measuring verbal intelligence, verbal intelligence quotient eight, has been found to be a valid and reliable measure (Theron 2013). It is important to bear in mind that when young children are being assessed on the JSAIS individually in research studies, as required by this psychometric test, it takes up to one and a half hours for an experienced psychometrist to assess each learner-participant, and this must be performed at a pre and post level, during the 'short school or calendar year', when permission was granted by the Gauteng Department of Education. Furthermore, sufficient time must be allowed during the relevant period to provide the 'treatment', for example chess tutoring (see Sala & Gobet, 2016). Subsequently, it leaves no time for pilot studies and/or adaptation of an 'older' psychometric test. Therefore, fellow researchers or experienced psychologists advise psychometrists to make notes about young children when being assessed and observe for abnormalities (for further investigation), and additionally tests, for example a 'draw-a-person test' can also be included (for further information) (Theron, 2013). If a child performed well at the baseline testing, and suddenly performs poorly on the post level psychometric test, a researcher also needs to look into it. In fact, this actually happened with one of the learners in S1, who displayed different results at a post level. Subsequently, the learner was sent to a 'special school' to address the necessary developmental problems in the following (Grade 1) year. Lastly, to adapt a measuring instrument with the purpose of improving validity, one must be very skilled lest the contrary might occur, thus reducing the validity.

4.1.1.6 Ethical Aspects. Prior to commencing the research, permission first had to be obtained from the Gauteng Department of Education, and the governing body of the Grade R school used in this research. Permission was also obtained from the ethics committee of the University of South

Africa, and from the parents and guardians of the children used as participants in the research (see appendices A, B and C, for further detail).

A registered psychometrist administered the psychometric testing in accordance with all the requirements and stipulations of the Health Profession Council of South Africa and this psychometrist also has extensive experience in using the JSAIS and other psychological tests in prior assessments. This was to ensure that the psychometric testing was done professionally and in accordance with the ethical standards governing psychological research (Foxcroft & Roodt, 2005, p. 116).

All the parents and guardians were informed about the purpose of the research, and they were asked to indicate their willingness to allow their children to take part in the research. To ensure that proper informed consent was obtained they were informed about the following in writing (see section 4; Appendix A and B):

The study was purely research oriented and was aimed at obtaining psychologically relevant information about chess instruction as an educational tool.

Participation in the research was voluntary and the children could withdraw from the study at any time without any consequences.

The results of the psychological assessments would be treated confidentially and only the researcher (and the statistician) would have access to the results.

Anonymity of the names of the participants is guaranteed.

Parents and legal guardians would be informed about the place and time when the assessments would take place.

Lastly, parents and guardians were thanked for allowing their children to participate in the study.

4.1.2 Stage 2: Learning Chess in Developmental Schools

As stated, the second stage investigates the effect of chess on young preschool children's cognitive and scholastic development in no-fee or developmental schools, and here 'school' itself becomes a variable, an independent variable. In this second stage the Grade R learners in some of the schools are exposed to chess learning, but children in the other schools do not receive any exposure to chess tutoring.

The first stage is conducted to determine if learning chess has any effect on young children's intellectual development, and the second stage extends the research to determine if learning chess can also affect the cognitive and scholastic development of young children in developmental schools.

The second stage involves a quasi-experimental design (and a qualitative comparison of teachers in three different developmental schools) used to determine whether chess tutoring has an effect on the intellectual and scholastic abilities (i.e., the early cognitive and aptitude skills development) of young pre-primary school children in developmental schools in the South African educational context.

4.1.2.1 Research Design. A quasi-experimental design was selected for collecting and analysing data, partially because full control could not be exerted on all the nuisance variables, but mainly because a non-probability convenience sample was used (Field, 2018, pp. 19 - 21). The influence of chess tutoring on the development of cognitive and aptitude skills of the young children was explored using *t*-tests and a 2X2 repeated measures analysis (on the post difference between two groups) who were analysed at two different time conditions.

The treatment variable, chess playing, is a categorical, independent, variable, because there were two different groups, a control group not exposed to chess instruction and no variables were manipulated), and an experimental group receiving chess instruction. The dependent (outcome) variable ‘scholastic aptitude’ is a continuous, interval scale variable measured on the full, multilingual, ASB (Aptitude Tests for School Beginners). This group test has eight different subtests, such as perception (thus measuring perceptual aptitude), spatial, reasoning, numerical, gestalt, coordination, visual memory, and verbal comprehension (as in verbal aptitude).

4.1.2.2 Sampling Process. The researcher was asked by one of the main chess initiatives in South Africa to adapt an existing Grade R chess curriculum, used in Stage 1, to the needs of Grade R learners in developmental schools in Stage 2. This researcher has not previously worked in historically disadvantaged areas; therefore, the Chess curriculum was adapted as best possible. Thus, a decision was made to select participants who were enrolled at Grade R pre-school facilities, due to the researcher’s affiliation with such schools as a Chess curriculum writer. Another reason for selecting learners in Grade R is that the literature highlights the benefits pertaining to this age group as well as the plasticity of learners’ brains for environmental influences (see also Inhelder & Piaget, 1958; Mateos-Aparicio & Rodriquez-Morena, 2019). A representative group of young children were then sampled from a Setswana and an English primary school, with African and Coloured children attending Grade R in developmental schools in the West Rand environment. Another school in the West Rand environment was initially included in this research investigation (and the Grade R learners were assessed at the first time point), but the researcher visited the school to collect biographical data more than once but the allocated teacher was absent from class each time and could not be found at the school. It was already extremely difficult to assess these learners on the ASB, and if assessed at a post level after receiving very little teaching, the testing process ASB would have been invalid.

The majority of schools in this area (if not all of them), formed part of a social upliftment programme during the relevant school year, where primary school learners would have received chess instruction or classes during school hours. Therefore, a developmental school not exposed to chess playing (a control group) was found in another area, Mamelodi. This Sepedi school consisted of predominantly African children, but not all the children spoke Sepedi at home. The children participating in the study were aged between 4 1/2 and 5 years at the beginning of the research.

The sample initially consisted of 122 learner-participants in Grade R classes in three primary schools in the Randfontein or West Rand area, and in Mamelodi (in the Tshwane district in Gauteng province). However, statistically it was reduced to 116 at a post level, when data cleaning was performed. The experimental or treatment group comprised 50 Grade R children who were not yet able to play a game of chess but were taught the basics of chess during chess classes at school.

There were 34 (-5) year old participants and 84 (+ 5) year olds in both groups, where (- 5) refers to learners who were not yet 5 years old by 30 June of that calendar year and (+ 5) year olds were already five years old by 30 June of that calendar year. Hence, it is possible that older learners are more mature than younger classmates, and will fare better on the ASB, therefore, age has become a variable in this current study, an independent variable.

The control group consisted of 66 Grade R children who were not exposed to chess instruction at school during the year. This is an unbalanced design due to the uneven cells in the two groups. However, this could not have been prevented due to various practical reasons. Although there were children with abnormalities in both groups, such as visual and poor muscle tone abnormalities, none of the children received any additional therapeutic or instructional interventions, but they were seen and assessed by members of a therapeutic team and feedback was given to the teachers about further plans for these learners.

The learner-participants selected for the research are assumed to be a reasonable representation of Grade R learners (ages 4 1/2 to 6) in developmental schools in South Africa.

Furthermore, the sample was homogenous with respect to educational status, as the participants were all in Grade R during the execution of the research. However, they were heterogeneous in terms of aspects such as age, culture, and language. English, Afrikaans, Sepedi, Setswana and Tsonga, were some of the twelve official languages (in South Africa) that these children spoke at home.

4.1.2.3 The Procedure. In the second stage, a non-probability, convenience sampling process was used to form two subgroups consisting of learners receiving chess instruction (the experimental group) at school, and a control group of learners of the same age at the Sepedi school, but who did not receive any chess instruction classes at school. The learner-participants in the chess group received chess instruction from the chess facilitator (allocated to the chess playing schools in the Krugersdorp Randfontein areas) and teachers of the Setswana and English schools. Thus, the experimental group received approximately 10 hours of chess instruction during the year (20 weeks over 2-3 terms). It is not known whether the participants in the control group received any chess tutoring during the period of the investigation but is of course possible that they could also have learned to play the game of chess, either from friends or with the aid of their parents. This is a situation which cannot be controlled for by the researcher. However, it should be noted that schools and communities in poverty-stricken areas usually have inadequate resources such as a lack of the necessary sport and recreational infrastructure, and it is therefore unlikely that they would have had the facilities to learn to play chess correctly on their own (Donald et al., 2006; Wells, 2012; Xaba & Mofokeng, 2021).

A consent letter was sent out to the parents with some background via the Grade R learners' backpacks, after the necessary departmental permissions were obtained (see Section 4.1.1.3). Parents or guardians were asked if they were willing to allow their children to participate in this current research investigation, and if they are willing to fill in a form to grant written consent to submit their children to the research study. All the relevant biographical data about the participating children were collected and recorded in the response booklets and on the computer for processing and safe keeping.

To establish a baseline, the (pre) test was subsequently administered in the ASB group test to all the participants during the course of the second term. This was done with permission from the Gauteng Department of Education, and the different school governing bodies and principals. The participants in the experimental group commenced with chess instruction during the latter part of the second term, after voluntary enrolment and after the first assessment at the first time point had been done. The different aptitude subtests of both groups were measured twice during the time interval by a registered psychometrist. For practical reasons, the psychometrist could not assess all the learner-participants at the second time level (in December), because, according to Parsons (2014) and the relevant teachers some learners stayed at home once the teachers had completed the Grade R curriculum. Consequently, the second assessment took place in November which limited the desired amount of time allocated to chess playing (Sala & Gobet, 2016; 2017). Furthermore, some of the participants in the English class had already left school at this stage and did not even return when the researcher contacted the parents. The problem here is that many learners make use of public (private) transport, and the longer they attend school, the higher the costs and additional expenses are for their parents.

4.1.2.3.1 How the Chess Instruction was Presented. The participants had to be taught the basics of chess with the aim of laying a foundation for further learning (also see Vaci, Bilalić, Edelsbrunner, Grabner, Neubauer & Stern, 2019; Van Vincetic, Brajkovic, Osijek & Pilj, 2018). The experimental group received approximately 10 hours of chess instruction during the relevant year

(20 weeks over 2-3 terms) and the duration of each (group) lesson was half an hour. The Grade R learners were introduced to the game of chess, but initially more in a demonstrative way. For example, at times, two classes of the Setswana school, would attend classes outdoors, where a huge chess (board) carpet and chess pieces were at display, followed by a demonstration of how to position the board and how the different chess pieces can move. Learners were given the opportunity to move the chess pieces, under supervision of the chess facilitator and teachers, which the young children apparently thoroughly enjoyed. After these lessons, participants did not always commence with chess playing on chess boards, due to various reasons, but they were asked to complete different chess activities related to different chess pieces and concepts in their Chess learner workbooks. The background of chess and the functions of the pieces were provided to the participants by adhering to Ericsson's (1988) requirements for developing high memory skills, as in the case of the participants in the former model C school (Basson, 2015; see Section 2.1.2).

For example, when a new chess piece was introduced to learner participants they were taught its functions in relation to other pieces, and learned how it moved on the board. Prior to each new chess lesson, the participants first revised what they had learned during a previous lesson with the aim of facilitating retention of their knowledge of the game. This was achieved by making use of different methods of instruction such as a variety of colourful pictures, different stories or explanations emphasising crucial concepts and themes, exercises in the Chess workbooks, clapping of movements of different chess pieces, followed up by a few practical assessments performed by two experienced chess players and instructors (namely the facilitator and the researcher).

During chess playing, the instructors assisted the participants by providing feedback, pointing out possible attacks and defences, offering suggestions and hints to improve their competence in chess and, also tried to enhance their self-confidence in their own playing ability

(Vygotsky, 1997; Ormrod, 2006, pp. 41-42). The guidelines of Tatjana Ogneva (2017), a Russian chess player and chess trainer, were followed (also see Storey, 2000). Tatjana recommends ample chess practice for young children following a chess curriculum, especially children with developmental problems (also see Islam et al., 2019; Karakaş, 2023; Meyers, 2005). The purpose of doing that is to free learners from stress, so that planning tasks such as to capture the king will not be so difficult for the children (Unterrainer, Halsband, Kaller, & Rahm, 2010; Unterrainer, Kaller, Leonhart, & Rahm, 2011).

After each chess lesson, the equipment was stored and the participants each received a small reward (a privilege or a star) if they performed in an acceptable manner. After the foundation had been laid during the introductory period, participants continued to practice their skills and were assessed by the researcher and chess facilitator in a practical learning situation during the third term. In these lessons attention was given to the following: the correct positioning of the board and chess pieces, taking turns to play, employing 'touch move', movements of at least the king, queen, rooks and pawn chess pieces, learning one or two openings, as well as one special move (for example castling) and certain principles. The children were also allowed to play against one another, two players during one time slot for each instructor, under the supervision of a chess instructor. All the learners were able to do these activities, but in a type of learning situation, where they were corrected when they did something wrong.

During the practical assessment sessions, different groups from one class at each of the schools in the treatment group were assessed in a separate vacant classroom. Different educational toys and activities were displayed on the carpet for learners while they were waiting for their turn to play chess. The learners seemed to enjoy this very much and wanted to continue playing with the educational toys. Furthermore, the instructors did notice that some learners displayed too tight 'pencil gripping' or poor fine motor skills as well as poor listening skills, therefore the educational toys could have enhanced some of the stated skills, as well. The latter was reported to the relevant teachers.

It should be noted that the teachers were not experienced chess players and they are unlikely to have realised that the CAPS curriculum and the Chess curriculum, written by the researcher, covered similar topics such as shapes, colours (colouring-in), counting, objects or roles of kings and queens, to mention just a few. Furthermore, the participants could not do some of the activities in the Chess workbooks such as cutting out pieces with scissors, because they were not taught how to use scissors in the school. Lastly, both schools in the chess group, were involved in chess playing in Grade 1, in the following year after receiving the ten hours of treatment in Grade R.

4.1.2.4 Describing the Measuring Instrument in Stage 2. The purpose of the test battery is to obtain a differentiated picture of certain aptitudes of school beginners, as this may assist psychologists to place learners in homogenous groups, where this is practically possible (Olivier & Swart, 1988, p. 1). Furthermore, with the obtained data and information, these reception stage learners can be educated inclusively particularly in small classes where children can undergo teaching and learning processes according to their own abilities because teachers can adapt their methods according to the needs and abilities of the children. Furthermore, some researchers (Olivier, Coetzee, & Swart, 1974; Olivier & Swart, 1988) argue that future scholastic achievement can be predicted by means of the obtained test scores (see also Grantham-McGregor et al., 2007).

There are two versions of the ASB psychological test, namely a full test battery, which was used in this research study, and an abbreviated test battery for the purpose of learners' placement (Olivier & Swart, 1988). All the different subtests consist of pictures, because the ability to read is not a prerequisite for executing the test, but the pictures have to be viewed from left to right in the correct reading sequence. The response booklets contain no colourful pictures, but various black drawings are printed on different colourful pages. The researcher was told by the test distributors (Mindmuzik Media, 2000) of the ASB, that some of the pictures in the Response booklets of this popular ASB test were recently changed to make them more culturally acceptable.

- The ASB consists of the following (1 – 8) tests, with 10 to 20 items:
- In Test 1 Visual perception, the ability to visually perceive is being assessed. Learners must choose the same option or picture as initially been provided (see Sections 2.4.1 – 2.4.4.3).
- In Test 2 (a Spatial test) participants must be able to rotate objects or figures up to 180 degrees, if needed.
- In Test 3 (in a Reasoning test), school beginners must be able to reason from a rule to an inference and choose the odd one out.
- Test 4, a Numerical or Arithmetic test assesses (in lay terms) age relevant mathematical reasoning (or arithmetic reasoning, one of the three important 'Rs' in Grade R), such as counting, quantities, proportions, and numbers.
- Leaners' perception of a Gestalt is being tested in Test 5, and it is important in reading and writing (two of the three 'Rs' important in Grade R). The ability to copy the provided examples (namely objects; a car, chair andor body parts) by linking linear dots, is also being tested.
- Thereafter, a pencil-in-hand Coordination test follows (from left to right), where the children 'move' with a pencil between lines when they draw a line as quick aspossible without touching the outer lines.
- Test 6 is followed by implicit, or non-intentional Visual Memory (of objects, people and/or animals as viewed during assessment) and lastly,

- Test 8 with Verbal and language comprehension (20 items), where a long sentence is being read, and the learner-participants choose the correct option.
- Olivier and Swart (1988) maintain that the last test which requires good listening and concentration skills, is the most important assessment of learning processes in the educational field. Manual scoring and norming of the Aptitude tests for School Beginners are done strictly in accordance with the 1988 and 1994 ASB Manuals (Olivier & Swart, 1988; Claassen, 1994).

4.1.2.5 Aptitude Tests for School Beginners (ASB). The background information pertaining to the development of the ASB group test and the Additional 1994 norms is provided in Olivier and Swart (1988, p. 44) and Claassen (1994). As they explain, a need arose in 1972 for the development of a measuring instrument that can be used to evaluate certain aptitudes, such as the ability to perceive visually and the ability to rotate objects spatially, which are regarded as important in elementary education and in the formal school years. Olivier and Swart (1988, p. 44) maintain that the tests were applied for item analysis to a representative sample of 1044 Grade 1 school beginners, selected from 46 schools in South Africa and also Namibia, which at that stage still formed part of South Africa. The learners were selected randomly according to the stratification method. Each of the then 7 test battery consisted of 15 items and the most suitable items were selected from this battery, resulting in 6 tests with 10 items and Test 5 (Gestalt) with 11 items. After this, the ASB was administered to a representative sample of 1796 school beginners for a standardisation purposes (Claassen, 1994, p. 4). The participants were selected randomly from a representative sample of 109 schools that were chosen according to the known stratification method (also see Claassen, 1994, p. 4, where Table 5.1 for the Distribution of Grade 1 Testers, according to province, territory and language medium [N =1796], is at display, for further detail). In addition to the application of the battery for the calculation of norms, a test of Verbal Comprehension was applied for item analysis and norms were determined for them.

A need arose in 1991 to establish new South African norms for the aptitude tests, and school learners were assessed on the ASB. Some changes had to be made to the samples due to the inaccessibility of some of the schools and in such cases other schools in similar socio-economic areas were selected. The eventual size of sample was moderate, comprising 5413 participants. A description of the sample of learners who were tested and the relevant values can be viewed in relevant tables in (Claassen, 1994), followed by the ASB - 1994 Norms for all South Africans (Claassen, 1994, p. 17).

The longest existing version of Test 8 (in English) was used with the aim to maximise reliability and it was then translated into seven African languages. Claassen (1994, pp. 3, 4, 10) reports that although great care was taken with the translation of the test, it remains a source of potential differential item functioning (DIF), where one index of DIF, is the correlation between item difficulties (Owen, 1992). Furthermore, DIF can help to ensure a fair, unbiased test, and refers to a statistical characteristic of an item that shows the extent to which the item could be measuring different abilities for members of other subgroups. Jensen (1980, as cited in Claassen, 1994, p. 10) argued that when the correlation coefficient is 0.90 or larger there need not be much concern about bias (also see Field, 2018, p. 227.).

Claassen (1994, p. 15) explains that pertaining to the revised 1994 Norms for subpopulations for non-environmentally disadvantaged children and for environmentally disadvantaged children in Tables 13 and 14, that the Socio-economic deprivation of children questionnaire (the SED Questionnaire, 1985, as cited in Claassen, 1994) was filled in by teachers and thereafter used to provide for cultural differences in groups. It was used to classify testers into a non-environmentally disadvantaged group and an environmentally disadvantaged group (also see Claassen, De Beer, Hugo, & Meyer, 1991, as cited in Claassen 1994). Moreover, ever since 1994, the full standardised 8 test group (or individual) test is available in the nine largest languages in South Africa, such as Afrikaans, English, Northern and Southern Sotho, Tsonga, Tswana, Venda, Xhosa and Zulu (Claassen, 1994, p. 3). The ASB measuring instrument has been compiled in such a way that, it is possible for any educator who has undergone some training to administer the tests (Olivier & Swart, 1988).

Manual scoring and norming of the Aptitude Tests for School Beginners is strictly being done according to the 1988 and 1994 ASB manuals (Olivier & Swart, 1988; Claassen, 1994, pp.1-2; p. 17). The different norms are represented in the different tables in the "Additional norms for the Aptitude tests for School Beginners, Norms for all South Africans", booklet by Doctor N.C.W. Claassen, 1994 (see Claassen, 1994 p. 17).

4.1.2.6 Administration of the ASB. Some researchers contend that the best time for administering the ASB is after at least seven weeks, but not longer than eleven weeks, of schooling in the first school year or during the last term of the Grade R school year, especially if there is doubt that a child is not ready for all the demands of a more formal school year (Olivier & Swart, 1988; Claassen, 1994, p. 2). The testing can be administered over one or two days, preferably in the morning. If the testing occurs over two days due to late comers, it is recommended that the first seven tests be administered on the first day of assessment and Test 8 (measuring Verbal aptitude) on the second day of assessment. However, this procedure is not practical in developmental schools, where teachers prefer that assessments are carried out in one day, so that learners can return to their normal routines. Also, the absenteeism rate amongst learners is high in these schools and some learners may not return on the second day so that these participants are then lost from the research study (see Weideman, Barry, Goga, Lopez, Macun & Mayet, 2007).

Before the ASB could be administered to the participants, ethical clearance was obtained (see Section 4.1.1.6) where ethical aspects are discussed for further detail. All the necessary specific arrangements for the assessments were made with the school principals, relevant class teachers, chess facilitator, assistants, and parents, firstly for suitable dates (and times) and (child-friendly) venues, with minimal noise and adequate lighting. Ample ASB Response booklets had to be obtained from the relevant distributor and participants' biographical data, class teachers' names and relevant dates were entered on each learner's booklet. Each page in the response booklets had to be straightened out prior to assessment, to prevent the learners from becoming distracted (Mateos-Aparico & Rodrigues-Morena, 2019; Ohiri, 2023; Ormrod, 2006). Extra (sharp) pencils were placed in a box with the Response booklets and lists of participants.

Breaks are normally given according to the manual and when needed, according to the discretion of the practitioner. Thus, the assistants had to be instructed, prior to assessments, that when children return from short breaks, it is crucial that they sit next to their own booklets again. The (pre) tests were administered to all the participants at the latter part of the first term, the experimental group first, with the purpose of gaining maximal chess exposure during the school year (Sala & Gobet, 2016; 2017). Before administering the structured ASB to the participants, everybody was welcomed and the process was explained by teachers in the language of learning and teaching, plus additional languages, as required, where possible. The researcher read instructions in English in the manual, and the teachers read it in the language of learning (or teaching) in a specific school. During assessments, it was important to make use of a few languages, where possible, and interchangeably, when an instruction was given, for instance Setswana and

English, especially when it seemed as if a learner did not understand an instruction. The latter was aimed at limiting nuisance variables to increase the internal stability of the test. For the sake of clarity, each instruction was coupled with examples and explanations illustrated on the black or green boards, and there were also practice examples included in the booklets.

The ability to read is not a prerequisite of the ASB psychological test, but when participants filled in their responses, they viewed the pictures from left to right, as in reading. It should also be noted that six of the eight tests in the ASB can easily be understood non-verbally by the learners, but that the exceptions are Test 4 (the Numerical test) and Test 8 (Verbal comprehension), which require specific verbal instructions per item. In some of the schools, the cleverer participants tried to complete the booklets on their own, and had to be cautioned. Participants were assessed according to the manuals and individual help was given to learners when needed, such as help with turning over of new pages, or guidance when participants were focusing on the wrong page.

Specific comments, (for instance for a child with gross abnormalities or certain habits) were made on the participants' individual booklets, for follow-up by the relevant teacher and to provide a more holistic picture (of quantitative and qualitative data) of learners' abilities (see Theron, 2013). For example, if a learner-participant performed poorly on the ASB, and restlessness was observed (and written by the researcher or assistants on the ASB booklet), it could be understood by the Researcher.

After the participants were assessed, all the response booklets and equipment were collected and placed in a cardboard box for safe-keeping and the learner-participants were thanked for their cooperation and hard work. The ASB was administered to all the participants in the same manner and although each school setting differs from one another, the assessments were still done under similar conditions. Furthermore, these conditions were highly standardised when the specific instructions were followed as dictated by the ASB manual in the hope that the internal consistency of the full battery of the ASB would remain high, thereby enhancing the validity of the test.

Luckily**,** due to the standardisation of instructions and scoring, the objectivity of the assessment procedure was ensured by the psychometrist, as assessment practitioner. The response booklets were scanned for unanswered questions and raw points were converted to scale points with the aim to compare them with the norms of the Aptitude Tests for School Beginners as well as with each other. The numerical data were captured on a spreadsheet (Microsoft Excel), with the help of an assistant, for further statistical (empirical) analysis, as described in the next chapter.

Lastly, the second (post level) assessment was done during November of the relevant year, before the participants' vacations would start.

4.1.2.7 The Reliability of the ASB. The ASB is a standardised measuring instrument and has acquired a relatively high reliability from about 0.80 to 0.90 and higher, according to Foxcroft and Roodt (2005, p. 46) and this is the case with: Tests 2, 3, 5, 6 and Test 7 values. All the subtests were calculated according to the Kuder Richardson formula 20 (KR-20), except Tests 5 and 6. Tests 1, 4 and 8 values ranged from 0.74 to 0.77, were calculated according to the KR-20 formula, slightly under the 0.78 value, but they are still regarded as acceptable. The subsequent standard error of measurement (SEM) values of the ASB varies from 0.26 to 0.50, reflecting the high reliability values of the tests (Olivier & Swart, 1988, p. 45). (The formula of Mosier was used to calculate the stated reliability coefficients). Lastly, Nunnally and Bernstein (1994) contend that when decisions about groups are being made, as in this research study, a reliability of 0.80 is adequate, and there are only two tests just below 0.80. For the additional 1994 norms, the reliability varied from 0.80 to 0.90 for Tests 1, 3, 5, 6 and 7 of the ASB (Claassen, 1994, see relevant Tables on p.14, for further detail; Olivier & Swart, 1988), which indicate high reliability in the norms. However, the KR-8 reliability coefficients for Tests 2, 4 and 8 ranging from 0.78 to 0.79 were lower, but also acceptable. Furthermore, Claassen postulates that all the items for all tests had positive discrimination indices for all the language groups (Claassen 1994, p. 7, see Table 5, where the KR-8 Reliability coefficients can be viewed, for further detail). With regards to Test 8, Claassen reports that the variability of the reliability coefficients appear to be slightly larger than for the other tests with 0.63 for the Northern Sotho language group, and 0.83 for the Afrikaans language group. Claassen argues that it is possible that the small sample sizes could have contributed to some instability in estimates (Claassen, 1994, p. 6).

The intercorrelations for each language group, were positive in all cases, but some of them were very low (see Brewer, 2007; Claassen, 1994, p. 5; George & Mallery, 2003). The inter-correlations for the English-speaking group ranged from 0.24 – 0.64 and the intercorrelations of the Xhosa-speaking group varied from 0.18 – 0.59 (these values can be viewed in Table 3). None of the differences between the stated two groups were found to be statistically significant at the 1 % level. Moreover, when a principal component analysis was done for each language group, in seven of the nine cases, only one underlying factor was found.

Now that one knows that the ASB is a reliable test, the validity of the battery will be discussed in the next section.

4.1.2.8 The Validity of the ASB Psychological Test. There are different types of validity, namely face validity, content validity, construct validity and criterion-related or empirical validity (Claassen 1994)**.** Content validity in such a test is very important therefore it will be discussed first. The ASB has evidence of content-description procedures, as in face and content validity, not only because of the familiar (black) drawings of people, animals and objects printed on different colourful pages, but also due to a meaningful content analysis and judgements made by a panel of experts.

4.1.2.9 Construct Validity. Claassen (1994, p. 6) contends that there is evidence for the construct validity of the eight subtests of the ASB for each language group, because when factor analysis was used to validate the measuring instrument, all the aptitude tests had a satisfactory loading of 0.36 or higher (ranging from 0.36 to 0.85) on the first principal factor (all measuring aptitude). However, a stricter cut-off score of 0.5 indicated the following: for the Xhosa language group, Test 2 was 0.44 for school beginners; for North Sotho, test 2 (0.47), test 6 (0.36) and test 7 (0.42) (altogether 4 out of 72 were above 0.5); did not meet the criteria of inclusion in the ASB for the evaluation of the different abilities, but they were still included for various reasons. Additionally, the factor loadings of the first principal factor (Table 11 is at display on Claassen, 1994, p. 15) for the eight tests of the ASB (no language groups relevant here) varies from 0.58 to as high as 0.78, all above 0.50. Furthermore, the communality values varied from 0.35 to 0.60; the specific variance(s) ranges from 0.78 to as high as 0.95 and the error variance(s) ranges from 0.08 to 0.22, very low.

Lastly, Claassen (1994) maintains that the above stated findings (1994, p. 15) indicate that a differentiated picture of abilities can be constructed on the basis of the ASB scores.

4.1.2.10 Criterion-Related or Empirical Validity. Developers of the ASB (Claassen, 1994, p. 7; Olivier & Swart, 1988, p.46) indicated that the ASB shows evidence of two types of criterion-related validity, namely predictive and concurrent validity. With regards to the predictive validity of the ASB, in a 1973 study, achievement in Grade 1 school beginners were taken and compared with the “testees’” achievements in December 1973, in certain school subjects. The correlations or validity coefficients can be regarded as satisfactory, because all the correlations ranged significantly from 0 the 1% level, although the correlations in Table 6.2 ranged 0.17 to 0.46 displaying very weak to moderate associations. Nevertheless, one can assume that the primary criterion to be predicted with the ASB is future school or academic achievement, and furthermore the ASB was being used as a baseline for probable improvements in cognitive and scholastic development after exposure to chess classes in this research study. Theron (2013) argues that when learners' levels of school readiness are being assessed, additional qualitative tests or ways of thinking should be considered, and one should bear in mind that emotional and social competencies are not being assessed with the usual school readiness tests (Van der Merwe, et al., 2022).

During 1992-1993, school beginners were again evaluated on a five-point scale by their class teachers at the beginning of the year on various aspects of behaviour, such as reading (Claassen, 1994 p. 7). When the Bravais-Pearson correlation coefficients were computed between the ASB tests and the teacher evaluations of the same aspects of behaviour for English speaking testers, there were only two correlations (the correlation between Test 3 and Visual memory [0.08] and the correlation between Test 4 and Auditive memory [0.07]), that were not significant at the 5% level.

For the Tswana speaking testees the range of the correlations were 0.12 – 42 (not very high), and one correlation between Test 7 and Auditive memory (0.12),

Finally, with reference to the predictive validity, Olivier and Swart (1988) contend that the specific variance in a test must be higher than the error variance, and that it must explain at least 25% of the variance to have adequate validity. The Numerical and Verbal Comprehension Tests were the only tests that failed and narrowly missed the stated criterion, with specific variance[s] and error variance[s] values of 0.22, just below the 25% cut-off point. On the other hand, the specific variance for the Co-ordination and the Visual Memory tests were quite large (0.54 and 0.57).

4.1.2.11 Ethical Aspects. Permission to conduct this current investigation was obtained from all the relevant parties such as the Gauteng Department of Education (GDE), the governing body of the English, Setswana and Sepedi schools and principals of the three primary schools, University of South Africa, and then lastly, informed consent was obtained from the parents and legal guardians. The psychometrist administering the psychological tests had to comply with all the requirements of the Health Profession Council of South Africa and had ample experience in psychometric assessment. All the above requirements had to be concluded in order to ensure that assessment practices were executed professionally and ethically according to the 1999 ethical code of professional conduct (Foxcroft & Roodt, 2005, p. 116; Grieve, 2005).

The rights of participants were stipulated in writing and they were informed about the following (see Appendix A):

- The purpose of the study, and no feedback of the assessments would be communicated to the parents and guardians, due to various reasons.
- Voluntary participation and withdrawal of the learner-participants.
- Confidentiality of the results of the participant assessments, and access to the results.
- Parents and legal guardians were informed about the location and the period when the assessments would take place.

Lastly, parents and guardians were thanked for their contributions.

4.1.3 Reliability and Validity in the ASB in this Research Study

Claassen (1994, p. 12) provided a summary of the statistical matters in the manual.

According to this researcher, with regards to the reliability coefficients, the intercorrelations of the tests, the factor structure, as well as the correlations with evaluations of scholastic achievement, no large differences were observed for the nine different language groups. Moreover, when the different language group means were compared, it appeared to be of similar size for the eight tests. As mentioned earlier, analyses at the item level did provide evidence of an unacceptable level of DIF, therefore an additional set of norms for all South Africans has been established and presented in the 1994 ASB manual.

As discussed above there is sufficient evidence for the reliability and for the different types of validity, such as content, construct, and criterion related validity of the Aptitude Tests for School Beginners' group test, but an experiment is only regarded as trustworthy when there is a high degree of internal and external validity. As seen in the discussion of the measuring instrument, a high validity can be obtained when the different aptitudes are being measured by the ASB psychological test but a lower degree of internal validity, probably due to less control over undesirable extraneous or confounding variables. For example, the participants in the control group could have been exposed to learning how to play chess from older children. These confounding variables could affect the dependent variable. (In this study, it refers to scholastic aptitudes or readiness for school). This may provide alternative explanations for the effects.

One should bear in mind that, in 2014, a pilot study was conducted by Parsons at a pre-school facility with young learners in similar poverty-stricken areas. The ASB mean scores improved significantly in the experimental group in a small-scale study with a small sample size. Most probably, the reasons for conducting such a study could have been, among others, to assist with the planning of a large-scale study, to determine the feasibility of the study protocol, to identify weaknesses in a study as well as to test whether the selected measuring instrument, the ASB, is appropriate for the target population (young children), and if the right questions are being asked. Lastly, a pilot study often precedes the main trial to analyse its validity.

Furthermore, the GDE granted this researcher only a short period of access to assess the learners twice a year (and to expose the participants to chess playing), probably with the purpose to not disturb/interfere with the learners' classes.

In Parsons' pilot study, the learner-participants' ASB mean scores increased significantly after a short period of chess exposure, by the researcher. This was also the case in Stage 1, when the JSAIS individual measuring instrument was used. One assessment can take up to an hour and a half, per learner at a pre level and approximately one hour at a post level, for an experienced psychometrist. Therefore, the psychometrist can also gain qualitative insight (a tastes amount of external validity) into how clever each participant is when assessed in research studies. Incongruencies would be detected (comparing the first assessment with the second one) and investigated. It has been noted/advised/recommended by researchers that other researchers/colleagues make use of more than one IQ/intelligence test (or worksheet/report) to obtain a holistic picture of learners' cognitive abilities of young or older children (Van der Merwe, et al. 2022).

However, there can be numerous threats to the internal validity of a study and in this study one of the following challenges had to be reckoned with.

Young Grade R learners are quite distractible and when they are assessed as a group, they can distract other learners as well, preventing them to work undisturbed and more whole-heartedly (McDevitt & Ormrod, 2013). Thus, when administering the group test some precautions had to be taken such as ensuring that there are enough staff members present during the testing, and that the instructions in the ASB Manuals were followed closely.

The multilingual ASB test was deemed to be the most suitable test to use if one takes both the multilingual nature of this country (i.e., there are twelve official languages) and affordability into consideration (Albertyn & Guzula, 2020). In this research, there was no randomisation, but there is still some ecological and external validity, although less than in a full experimental design.

4.2 Summary

In this research methodology chapter, the research design, sample, and sampling process were described, as well as the processes of data gathering and data capturing were described in two studies, one in Stage 1 in a homogenous former model C school in Pretoria, and another study in Stage 2, in a heterogenous environment in developmental schools in the West Rand and Mamelodi. The measuring instruments, the Junior South African Intelligence Scales and the Aptitude Tests for School Beginners, used to measure the Grade R learners' performance (aptitude and cognitive development) in this research study, has been discussed and is deemed to be a reliable assessment instrument. The procedures for administering the ASB and capturing the data were discussed, as well as possible limitations in this study. In the next chapter statistical data analyses of the collected data will be performed to investigate the model.

Chapter 5

Results

In this chapter, the results of the two stages of the research are presented. The chapter begins with a description of the results of Stage 1 of the research, which was conducted in a standard Model C public school. As explained in the previous chapter, this part of the research was initially carried out and described in Basson (2015) and is reproduced here for contextual purposes. Thereafter, the results of the data analysis of Stage 2 of the research project are presented, which entailed an extension of the research to schools in a developmental context. The latter aspect was the focus of the current research, the results of which are described in detail.

5.1 The Quintile 5 Grade C School – Stage 1

This research was conducted with Grade R preschool children in a single model C school and this study formed the first stage of the overall research project. The study investigated the relation between chess instruction and the development of cognition and intelligence, and the research was situated in the theoretical framework of the novice-expert shift in cognitive psychology in two stages (De Groot, 1946; 1978; Vaci & Bilalić, 2016; Vaci, et al., 2019).

A sample of 64 Grade R learners from a Quintile 5 (homogenous for culture and language) school in Pretoria was divided into two groups. One served as a control and these children were not exposed to chess instruction. The other group, referred to as the treatment or experimental group, were exposed to 40 weeks of chess classes. Both groups were assessed twice on the Junior South African Intelligence Scales, first prior to the onset of the treatment (i.e., the chess intervention) and then again after the treatment had been provided. All these learner-participants turned six in the relevant calendar year, except two learners/participants who were not removed from the study year.

The four research questions (H1-H4) were tested using One-way ANOVA (GLM 1) and MANOVA with repeated-measures (GLM 3) on one factor. A mixed design with two between factors and one within factor was used with the repeated-measures design. The following variables were created for the purpose of data analysis.

- *Treatment* or *chess instruction* (with two levels, no treatment or 20 hours' treatment);
- *Groups* (the experimental group and the control group);
- *Gender* (boys and girls);
- *Intelligence* or *cognitive development* as represented by scores on the subscales and global scale of the JSAIS of the two groups; and
- *Time* at two levels, namely the pre-test condition at the beginning of the year and onset of the investigation and the post-test condition at the end of the year.

5.1.1 Testing the Parametric Assumptions

The four assumptions required for the parametric statistical techniques employed ANOVA and MANOVA for the data analysis are now briefly discussed.

5.1.1.1 Normality of Distribution. The Shapiro-Wilk Test was performed at two different periods to assess whether the distribution of the variables (scores or data) to be analysed are normal for the two independent groups (N=64) at the two conditions or periods. Simple comparisons of the mean as well as the Shapiro Wilk statistic were used to make decisions regarding the normality. The intelligence scores of the global scale and subscales of the JSAIS for the two groups, namely the experimental and control groups, and for the two periods were normally distributed at a 95 % level of confidence ($p > 0.05$). Furthermore, as the sample size of the two groups exceeds the minimum limit (N = 30) specified by the Central Limit Theorem, a parametric technique can be used for data analysis (Howell, 2010).

5.1.1.2 Homogeneity of Variances. A one-way ANOVA was conducted to examine whether there were statistically significant differences among the different levels of chess instruction in relation to the mean intelligence performance scores. The ANOVA indicated that intelligence (represented by scores on the JSAIS) met the assumption of equal variances between the two groups at the PRE level or pre-test condition prior to the manipulation of treatment (chess instruction). The results revealed no significant differences between the two groups' intelligence scores (mean PIQ, VIQ, GIQ and Num scale scores) for different chess levels at a 95 % level of confidence as the *p*-values were all larger than 0.05 [PIQ], $F(1,62) = 0.176$ ns; VIQ, $F(1,62) = 0.329$ ns; GIQ, $F(1,62) = 0.600$ ns and Num scale, $F(1,62) = 0.403$ ns.

Levene's tests also indicated that intelligence scores met the assumption of equal variances for the two groups at the PRE level. In a series of Levene's tests, the *p*-values of the PRE level are all greater than 0.01 alpha level [PIQ], $F(1,62) = 0.479$ ns, VIQ, $F(1,62) = 0.9741$ ns, Num scale, $F(1,62) = 0.966$ ns and GIQ, $F(1,62) = 0.478$ ns; hence, also indicating no significant differences at a 99 % CL. At the POST level or post-test condition, the *p*-values from the Levene's test are also greater than 0.01 AL [PIQ], $F(1,62) = 0.426$ ns; VIQ, $F(1,62) = 0.216$ ns; Num scale, $F(1,62) = 0.085$ ns and GIQ, $F(1,62) = 0.375$ ns, at a 99 % CL. Therefore, one can conclude that the intelligence scores for the different chess levels (the C and E groups) met the assumption of equal variances. This assumption is especially important in a repeated measures design because, when testing variances for equality, it is essential to ensure that no group starts off with an advantage prior to the manipulation of the treatment compared with the experimental group (see Appendix D [1 – 6]).

5.1.1.3 The Use of Interval Data. In this study, interval data with equal distances and equal differences between points on scales, tables and/or in profile plots, were used (Appendix D [1 – 6]).

5.1.1.4 Independence of Data. Independence of data is also required, which implies that the intelligence scores of the different participants are independent of each other. Field (2018) contends that, in a repeated-measures design, it can be expected that the scores of a participant in the experimental condition must be non-independent for a specific participant. However, when referring to the behaviour of the participants between participants it should be independent, as in the case in this study.

The analyses in this section were conducted using IBM SPSS version 21.

5.1.2 Testing the First Research Hypothesis of Stage 1, RH1_S1

The first hypothesis was to determine if there is a difference in the mean scores obtained for both groups between the two (pre and post) time points. It is expected that there would be an improvement in the JSAIS general Intelligence (GIQ) scores that can be attributed to normal cognitive development of both groups over the 20-hour period. A multivariate repeated-measure analysis of variance was conducted to establish whether there is any support for this hypothesis.

Table 5.1 indicates the descriptive statistics for the variable GIQ (general intelligence) for the two periods.

Table 5.1

Mean Sample Sizes and Standard Deviations of GIQ on the pre- and post-time periods

	Mean	Std. Deviation	N
GIQ PRE	101.578	7.3933	64
GIQ POST	108.063	7.3352	64

Table 5.2 sets out the results of a repeated-measures ANOVA comparing the scores that the two groups together obtained on GIQ at the two time points. As evident in the table, there was a significant effect for time, Wilks Lambda = .403, $F(1,62) = 93.151$, $p < 0.000$*, with a large

contribution of about 60 % variance to GIQ (eta square is 0.597).

Table 5.2

Multivariate tests of Time[a]

Effect		Value	*F*	Hypothesis DF	Error DF	Sig.	Partial Eta Square
Time	Pillai's Trace	0.597	93.151[b]	1.000	63.000	0.000	0.597
	Wilks' Lambda	0.403	93.151[b]	1.000	63.000	0.000	0.597
	Hotelling's Trace	1.479	93.151[b]	1.000	63.000	0.000	0.597
	Roy's Largest Root	1.479	93.151[b]	1.000	63.000	0.000	0.597

a. Design: Intercept Within-Subjects Design: Time

b. Exact statistic

CL 95%

The following conclusions can be drawn from the data presented in Table 5.2. Hypothesis H1_S1 is supported because the JSAIS scores of both groups improved over the period. There is a statistically significant main effect (time) at a 95 % level of confidence $F(1,63) = 93.151$, $p < .000$* and a large effect size (eta square is .597).

5.1.3 Testing the Second Research Hypothesis of Stage1, RH2_S1

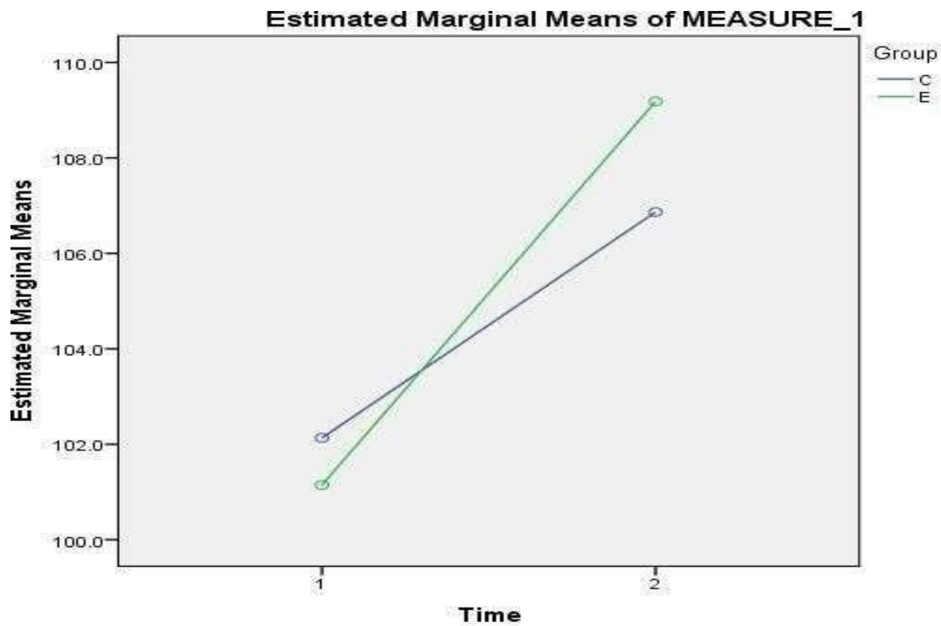
To test hypotheses 2 and 3, a repeated measures ANOVA, with two factors (group and gender) was conducted. The ANOVA summary is presented in Table 5.4.

The second hypothesis posits that there would be an interaction between group and time, and that the GIQ scores of the treatment or chess group would improve significantly more than those of the control group. It is evident in the profile plot in Figure 5.1 that the scores of the E group were lower than those of the C group at the pre-test time point but larger at the post-test time point. The post-test GIQ mean score of the experimental group was 109.12, whereas the post-test mean score of the control group was 106.12.

The profile plot indicates that there was an interaction between group and time.

Figure 5.1

Profile plot of interaction between group and time



To determine whether the difference is statistically significant, a repeated-measures ANOVA analysis must be conducted but before doing so, the issue of sphericity should be considered (see Appendix D [1 - 6]).

Mauchley's test is not relevant with only two groups but is nonetheless reported because there are three factors (time, group, and gender) in the repeated-measures ANOVA. The table below indicates that Mauchley's test for sphericity was not significant indicating that the assumption of sphericity was not violated by the data. This is also confirmed by the Greenhouse Geisser correction which is 1 in Table 5.3 (tests for sphericity)

Table 5.3

Tests for Sphericity

Mauchly's Test for Sphericity[a]							
Within-Subjects' Effect	Mauchley's W	Approx. Chi-Sq.	DF	Sig.	Epsilon[b] Greenhouse Geisser	Epsilon[b] Huynh-Feldt	Epsilon[b] Lower-Bound
Time	1.000	0.000	0	.	1.000	1.000	1.000

a. Design: Intercept and Group/School/Teacher, and Within-Subjects Design: Time

b. It may be used to adjust the degrees of freedom for the averaged tests of significance.

SPSS (2020): Tests the H0 that the error co-variance matrix of the ortho-normalised transformed SR scores is proportional to an identity matrix.

Tables 5.4 and 5.5 set out a summary of a repeated-measures ANOVA with the independent variables, time, group, and gender, and GIQ as the dependent variable. 'Kids' is an abbreviation used for children in the tables.

Table 5.4

ANOVA summary table, within contrasts

Tests of Within-Subjects' Contrasts							
Source	Time	Type III Sum of Sq.	DF	Mean Square	*F*	Sig.	Partial Eta Sq.
Time	Linear	1287.401	1	1287.401	94.064	0.000	0.611
Time * Gender_Kids	Linear	0.381	1	0.381	0.028	0.868	0.000
Time * Group	Linear	86.163	1	86.163	6.296	0.015	0.095
Time * Gender_Kids * Group	Linear	5.260	1	5.260	0.384	0.538	0.006
Error (Time)	Linear	821.187	60	13.686			

N=64

Table 5.5

ANOVA Summary of Between-Subjects' Effects

Tests of Between-Subjects' Effects						
Source	Type III SS	DF	Mean Square	*F*	Sig.	Partial Eta Square
Intercept	1388774.726	1	1388774.726	14132.750	0.000	0.996
Gender*Kids	13.420	1	13.420	0.137	0.713	0.002
Group	13.967	1	13.967	0.142	0.707	0.002
Gender*Kids* Group	0.728	1	0.728	0.007	0.932	0.000
Error	5895.985	60	98.266			

Table 5.5 shows that the *p*-value for the factor Group is greater than 0.05 AL $F(1,62)$ = 0.142, p = 0.707 ns, indicating that there was not a significant difference between the two groups at the pre-level. The repeated-measures ANOVA analysis in Table 5.4 confirms that the Group × Time Interaction was statistically significant $F(1,62)$ = 6.296, p = 0.015* as already suggested by the profile plot. However, the effect size is quite small because partial eta square is 0.095, implying that only 9.5% variance is due to the time by group interaction. Hypothesis 2 is supported by the data because there was a statistically significant interaction between time and group, and the chess group improved more than the control group over the period as predicted but the effect size was small.

5.1.4 Testing the Third Hypothesis of Stage 1, RH3_S1

The repeated measures ANOVA summary in Table 5.4 can be consulted to determine whether there was any significant interaction between the groups and gender over time. As indicated in the table, there is no significant effect of time on the gender variable $F(1,62) = 0.028$, $p < 0.868$ and no significant interaction between gender and group over time $F(1,62) = 0.384$, $p = 0.538$, 95 % CL.

Hypothesis 3 is therefore not supported as there was no statistically significant interaction between gender and group during the period being considered.

5.1.5 Testing Research Hypothesis 4 of Stage 1, RH4_S1

To recapitulate briefly, the repeated-measures ANOVA results indicated that the Group by Time interaction was significant, $F(1,60) = 6.296$, $p = 0.015$*. Tests for simple effects revealed that the mean GIQ score for both the control group $F(1,62) = 25.69$, $p < 0.000$* and experimental group $F(1,62) = 81.23$, $p < 0.0001$ [95%CL] displayed significant differences across time. The GIQ scale results comprise three subscales, VIQ (verbal Intelligence), Numeric (numerical intelligence), and PIQ (performance intelligence). The next step is to establish how these subscales contributed to the group by time effect reflected in the GIQ scores. This research question was addressed in two stages. First, a repeated measure multivariate test with three dependent variables (VIQ, Numeric, and PIQ) was conducted, with the gender and group variables. These results are displayed in Table 5.6 (Field, 2018).

Table 5.6

Multivariate analysis of within-subjects' contrasts for the 3 subscales

Level	Measure	Time	Type III SS	DF	Mean Square	Exact *F*	Sig.	Partial Eta Square	Noncent. Parameter	Observed Power[a]
	PIQ	Linear	139.359	1	139.359	5.175	0.026	0.078	5.175	0.610
	VIQ	Linear	182.426	1	182.426	7.686	0.007	0.112	7.686	0.779
Time	Num	Linear	0.212	1	.212	0.097	0.757	0.002	0.097	0.061
	PIQ	Linear	0.002	1	.002	0.000	0.994	0.000	0.000	0.050
Time *	VIQ	Linear	4.149	1	4.149	0.175	0.677	0.003	0.175	0.070
Gender_Kids	Num	Linear	1.835	1	1.835	0.839	0.363	0.014	0.839	0.147
	PIQ	Linear	109.853	1	109.853	4.079	0.048	0.063	4.079	0.511
Time *	VIQ	Linear	28.832	1	28.832	1.215	.275	0.020	1.215	0.192
Study_condition	Num	Linear	3.618	1	3.618	1.655	.203	0.026	1.655	0.245
	PIQ	Linear	1642.814	61	26.931					
	VIQ	Linear	1447.799	61	23.734					
Error (Time)	Num	Linear	133.380	61	2.187					

*Computed using alpha 0.05

The results displayed in the Table 5.6 show that the only statistically significant difference between group and time occurred with regards to the PIQ subscale $F(1,62) = 4.079$, $p = 0.048$* [95%CL] and the effect size is small (eta squared = 0.063). These results were confirmed with a one-way repeated-measures ANOVA with group as the independent variable and PIQ as the dependent variable. As there are only two groups, Mauchley's test is not relevant. The within subject contrasts are shown in the Table 5.7, and the group by time interaction was significant $F(1,62) = 4.148$, $p = 0.046$* at a 95 % CL.

Table 5.7

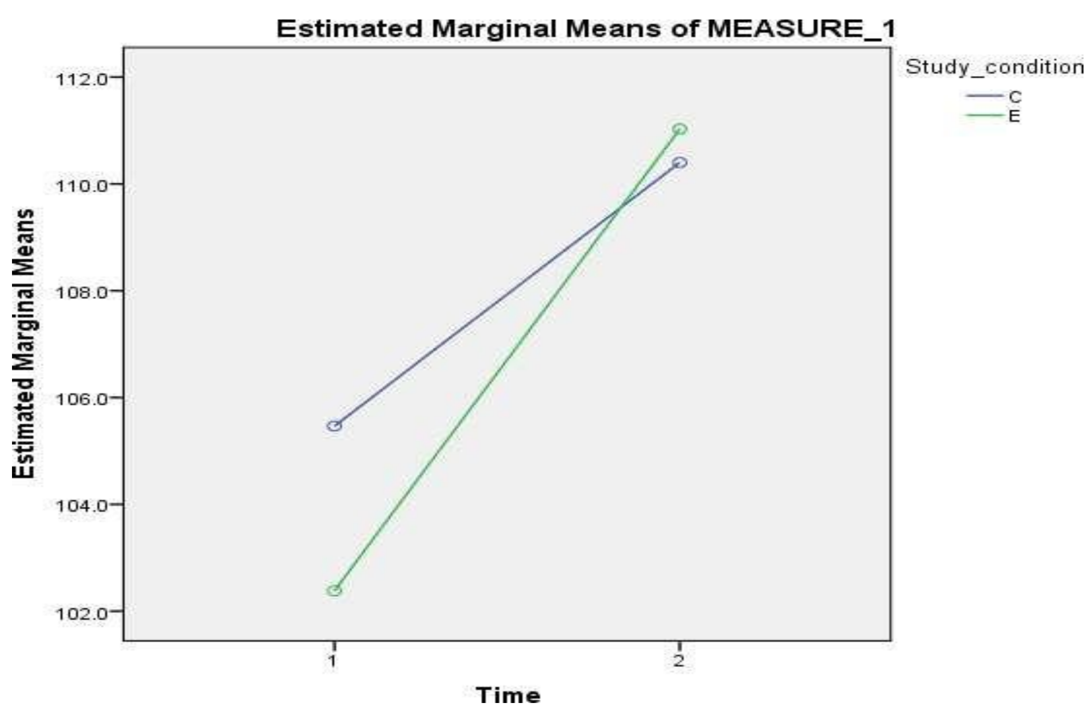
Tests of Within-Subjects' Contrasts for PIQ

Source	Time	Type III SS	DF	Mean Square	*F*-ratio	Sig.
Time	Linear	1469.653	1	1469.653	55.46	0.000
Time*Study*Condition	Linear	109.903	1	109.903	4.148	0.046
Error (Time)	Linear	1642.816	62	26.497		

The profile plot for the interaction between group and time for PIQ is shown below.

Figure 5.2

Profile plot of group by time interaction for PIQ



The following summary represents the main findings emanating from this phase of the research.

5.1.6 Section Summary

The results revealed statistically significant differences between the group means of the

Performance intelligence or Fluid scale [PIQ] and the Global intelligence scales [GIQ] at a 95% level of confidence; [PIQ], $F(1,62) = 4.15$, $p = 0.046$* and [GIQ], $F(1,62) = 6.25$, $p = 0.015$* which indicates a relation (interaction of combined effect) between chess instruction over time and intelligence. The magnitude of the relation (partial eta square = 0.063) was small, with the time factor (and not the chess factor) contributing more to this relation.

5.2 Extending the Research, Stage 2

In this second stage, the focus is still on young children (Grade R) learner-participants but this time the research was carried out with three no-fee or Section 21 schools, instead of the Quintile 5-type school reported in Section 4.2. In this stage of the research, the objective was to explore the effect of learning to play chess on the development of young children's cognitive scholastic performance in historically disadvantaged areas. The 122/116 participants from different schools were sampled in a non-randomised method/manner to form a convenience sample, and constituted two groups, an experimental group (50) and a control group (66). There were 98 Black children and 18 Coloured children in the three schools, and 86 spoke Setswana and Sepedi at school, but were also exposed to different languages at home and in the different communities. The treatment and control groups were then compared on a multilingual Aptitude Test of School Beginners (ASB) at two different time points to establish whether chess playing had any effect on the school-readiness scores of the children over time.

The two groups under study consisted of a Sepedi school in Mamelodi which was the control or C group, and two Setswana and English schools in the Randfontein area, which constituted the treatment group. In this case, the experimental group formed part of a social upliftment programme.

5.2.1 Variables Used

The following variables were created for the data analysis of part of the investigation.

• *Groups:* An independent variable/IV consisting of 66 learner-participants in the C group and 50 learner-participants in the E group;

• *Chess instruction:* An independent variable and an intervention with two levels, no treatment, or 10 hours of tutoring over 20 weeks;

• *Time:* An independent variable referring to two time points or conditions during the relevant calendar year (referring to Total PRE and Total POST), as indicated on a profile plot;

• *School preparedness:* as represented by scores on the tests of the ASB, as the outcome/response or dependent variable;

• *Age:* (-5 and +5) and *gender* (52 boys and 64 girls): Both categorical variables with two different groups, 2 age groups, with one group turning five years by the end of June (-5) in the relevant school year and the other group turning six years (+5) during the time-period, and two genders, referring to boys (B/M) and girls (G/F), and

• *Schools:* Two schools (with 50 learners) in the Randfontein area and one in Mamelodi (66), with five classes altogether (two classes in the E group and three classes in the C group) nested under them together with the five accompanying teachers and learners.

In this research, Cohen's D effect size was used to magnify (within-subjects') effects in matched pairs. Partial eta square effect sizes were used to express and quantify the power of the sample for specific tests and assumptions such as one way ANOVA and MANOVA based on Cohen's (1992) guidelines. The 95% confidence level (CL) was applied in the parametric tests, except where tests required different confidence levels such as the Levene [0.01] and O'Brien equality tests [0.5 AL]).

5.2.2. Data cleaning and Demographical Data

At the beginning of this study, the sample consisted of 122 (67 + 55 = *N* 122) learners-participants in Grade R classes in three primary schools in the Randfontein area and Mamelodi but this sample size was reduced to 116 at a post level after data cleaning had been performed. Tables 5.8, 5.9, and 5.10 show the representation of the learners in the three schools, the SR scores at the two time points, and the mean sample sizes, and standard deviations of groups, gender, age, and schools.

Table 5.8

Mean Sample Sizes of Participants in different Groups (C and E), Schools and Classes (Post level)

	Group_2							
	Control: Teacher				Experimental: Teacher			All
Primary Schools	Sepedi A1	Sepedi A2	Sepedi A3	All	Setswana	English	All	
Sepedi School	25	19	22	66	0	0	0	66
English School	0	0	0	0	0	30	30	30
Setswana School	0	0	0	0	20	0	20	20
All	25	19	22	66	20	30	50	116

N=116

Table 5.9

Summary of mean sample sizes of SR of learners in different groups, schools and classes at the 1st and 2nd time points (pre and post)

		Group_2											
		Control				Experimental				All			
		Total PRE		Total POST		Total PRE		Total POST		Total PRE		Total POST	
School	Teacher	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean
SEPEDI	Sepedi A1	25	39.30	25	64.90	0	.	0	.	25	39.30	25	64.90
	Sepedi A2	19	37.89	19	63.82	0	.	0	.	19	37.89	19	63.82
	Sepedi A3	22	35.00	22	56.36	0	.	0	.	22	35.00	22	56.36
	All	66	37.46	66	61.74	0	.	0	.	66	37.46	66	61.74
ENGLISH	English	0	.	0	.	30	42.83	30	55.42	30	42.83	30	55.42
	All	0	.	0	.	30	42.83	30	55.42	30	42.83	30	55.42
SETSWANA	Setswana	0	.	0	.	20	49.13	20	55.50	20	49.13	20	55.50
	All	0	.	0	.	20	49.13	20	55.50	20	49.13	20	55.50
All	All	66	37.46	66	61.74	50	45.35	50	55.45	116	40.86	116	59.03

Table 5.10

Summary of mean sample sizes and std. deviations of groups (age and gender categories), schools and teachers (classes) at a post level

Level		N	Mean	Std. Dev	Lower 95%	Upper 95%
Groups	Control	66	24.280	9.939	21.836	26.723
	Experimental	50	20.1	9.160	7.496	12.703
Gender	Female	66	18.787	11.479	15.965	21.609
	Male	50	17.35	12.478	13.803	20.696
Age	-5 years	23	22.065	10.783	17.402	26.728
	+5 years	93	17.204	12.005	14.731	19.676
Schools:	Sepedi	66	24.280	9.939	21.836	26.723
	English	30	12.583	8.795	9.298	15.867
	Setswana	20	6.375	8.602	2.349	10.400
Teachers:	Sepedi A1	25	25.6	9.445	21.701	29.498
	Sepedi A2	19	25.921	8.002	22.064	29.777
	Sepedi A3	22	21.36	11.642	16.201	26.525
	English	30	12.921	8.795	9.298	15.867
	Setswana	20	6.375	8.602	2.349	10.400

N = 116

5.2.3 Testing the Parameter Assumptions

The primary assumptions in ANOVA to ensure reliable testing are that: (a) the responses for each factor level have a normal population distribution, (b) the distributions have the same or equal variances, and (c) the data are independent (see Appendix D [1 – 6]).

5.2.3.1 Normality. Inspection of the histograms, boxplots, and summary statistics showed that the data do meet the assumption of normality. In addition, the sample size is larger than (*N*=30) so that normality can be assumed in terms of the Central limit Theorem (Howell, 2010).

5.2.3.1.1 Distributions (of Diff Total). The data are normally distributed with a skewness of

0.047 and Kurtosis of -0.370, and there is no violation present (quantiles [max] = 47.5, 27.5, 10 and [min] = -12.5, median = 18.75, mean = 18.168, Std Dev = 11.888, Std. Err of themean 1.103, endpoints: 15.981 20.35/95% CL), *N* = 116).

5.2.3.1.2 Distributions of Total Pre. The distribution of the data also meets the assumption of normality at the *pre* level. The data are normally distributed with a skewness of 0.268. The mean (40.) and the median (40.862) are almost 100 % equal; the std. dev. = 10.263, the std. error of the mean = 0.952 (with endpoints: 38.974 - 42.749/95% CL) and *N* = 116. There was no violation of the normality assumption but there were some outliers in the summary statistics and 11 rows were excluded prior to the data analyses (see Appendix D [1- 6] for further detail).

5.2.3.1.3 Distributions of Total Post. Lastly, the distribution of the data also meets the assumption of normality at the *post* level. The data are normally distributed with a skewness of -0.388. The mean (60.) and the median (59.030) were almost 100 % equal/similar; the std. dev. = 12.255, the std. error of the mean = 1.137 (with endpoints: 56.776 – 61.284/95%) and *N* was 116.

Where the normality assumption was not met, non-parametric (or assumption-free) tests and bootstrapping techniques were used and, large samples (i.e., a sample size of more than the minimum of 75, as in the current study), to compensate for such inequalities (see Appendix D [1 - 6] for further detail).

5.2.3.2 Homogeneity or Equal Variances. The values of the Levene tests performed indicated that the ASB scores met the assumption of homoscedasticity between the C and E groups, as well as the difference total regarding schools, teachers, and two age and gender categories. This was the case not only at the first time point but also importantly with respect to the second timepoint at a post level.

The *p*-values obtained in a series of Levene tests are as follows: At the *post level*, the *p*- values of all the Levene's tests and all the equality tests (except for O'Brien's test .5 CL) are all greater than the 0.01 CI, indicating no significance at the 99% confidence level.

For Groups/ASB (Diff at post level), Levene test, $F(1,114) = 0.021$, $p = 0.883$ ns; for Gender (M/F)2: Levene test, $F(1,114) = 0.417$, $p = 0.519$ ns;

For Age (less than 5 and older than 5) 2, Levene test, $F(1,114) = 1.439$, $p = 0.232$ ns; For Schools, the Levene test, $F(2,113) = 0.803$, $p = 0.450$ ns and for Teachers, the Levene test is, $F(4,114) = 0.920$, $p = 0.454$ ns, at a 99 % CL.

Furthermore, none of the other tests for homogeneity or equal variances were statistically significant (see Appendix D, where the equality tests are presented). The assumption of homogeneity of variances was therefore met in this research investigation (see Appendix D.2 for further detail).

5.2.3.3 Independence of Data and Independent Error or Residuals. This assumption is especially applicable when employing a repeated measures design in ANOVA and MANOVA, because the same participants are being used at the two time points, that is, at pre and post levels. The Grade R learners (in the C and the E groups) were assessed on the ASB test twice but after completion of the first test, the correct answers were not provided, and the test was not discussed with them. With such young learners and their still limited working memory stores, it is very unlikely that they will be able to remember a test with different subtests verbatim. It is therefore reasonable to assume that the first testing will not have a significant influence on their second testing with the ASB test.

Additional assumptions are needed for multivariate testing and in repeated-measures designs applicable when there are more than two groups, for example, testing the *H0* that the observed matrices of the DV (SR) are equal across groups with a Box's test of equality of covariance matrices and sphericity by making use of Mauchly's test of sphericity. With reference to sphericity in this research investigation, there are only two groups; therefore, sphericity tests are not required for MANOVA. For a Box's *M* value of 14.178 (for teachers in the C and E groups) in a SPSS analysis there was no significance; therefore, the *H0* can be accepted, $F(12{,}692.744)$, = 1.135, p = 0.326 ns (see Appendix D [1 – 6] for further detail).

The next section sets out the statistical techniques used in each of the research hypotheses (RH1 – RH5), as presented in section as well as the results of the investigation.

5.3 Presentation of the Research Hypotheses Under Investigation

The five hypotheses are presented below.

(RH1_S2): Both (C and E) groups will exhibit higher levels/average means of school readiness (SR) (within-subjects) at the end of the time interval after being exposed to a Reception Phase programme. This is a directional hypothesis and it is predicted that the post-test ASB scores of both groups will be significantly higher than their pre-test scores as measured on this instrument.

(RH2_S2): By the end of the school year, there will be significant differences between the (C) and the (E) groups. The Chess group (E) will display higher ASB scores/means than the C group, after being exposed to 20 weeks/10 hours of chess tutoring.

(RH3_S2): There will be a significant difference in the two age groups of the Grade R learner-participants; the older learners (+ 5 year) will do significantly better than the younger Grade R learners (- 5 year).

(RH4_S2): Factors like gender will display a different relation with SR. There will be a significant difference between the boys' and girls' ASB mean scores, in the control and experimental groups; the boys will display higher SR scores at the second assessment or time point.

(RH5_S2): There will be significant differences amongst participants in relevant *no-fee* schools, classes (and teachers), as well as a different 'order of performance', between the different schools, and classes of teachers in this current investigation. The two schools in the treatment groups will display higher mean ASB scores after exposing the learner-participants to 20 weeks of chess playing.

5.4 Summary of Statistical Techniques Used in Separate Research Hypotheses (RH 1 - 5)

The research questions were investigated using both descriptive statistics and the relevant inductive statistical techniques. As there were only three schools, multilevel modelling could not be used, and therefore group, school, and teachers had to be analysed separately.

Table 5.11 displays the analyses used for testing each hypothesis.

Table 5.11

Summary Table of the Analyses used for the Hypotheses of Stage 2

H1 (Within subjects: time)	Applicable Assumptions for statistical Analyses (Appendix D) With applicable tests).	Matched paired *t* tests (Cohen's D effect size)	Pooled *t* test and Welch test ANOVA	MANOVA (Least Squares Means) Parametric tests All within interactions (Tests of Within-subjects' effects) Partial eta sq.	
H2 (Between-groups)	Applicable Assumptions for statistical analyses (with the applicable tests).	Pooled *t* test	(Cohen's D effect size) ANOVA + effect Size Welch test ANOVA	MANOVA (LSM) Parametric Tests All between group_2	
H3 (age/months [-5/+5 age])	Applicable Assumptions for statistical analyses (with the applicable tests).	Pooled *t* test	Welch *t* test ANOVA	MANOVA: (LSM) Parametric Tests	
H4 (Gender: B/G)	Applicable Assumptions for statistical analyses (with the applicable tests).	Pooled *t* test	ANOVA	MANOVA: (LSM) Parametric Tests	All Between Subjects Partial eta square
H5 Schools	Applicable Assumption for statistical analyses (with the applicable tests).	Welch test	ANOVA/MANOVA	Tukey-Kramer HSD Threshold Matrix and Connecting Letters Report + Ordered DifferencesReport Steel-Dwass Method	Partial effect size (for 'within-interactions', butnot for 'all between interactions)
H5 Teachers	Applicable Assumption for statistical analyses (with the applicable tests)	ANOVA	Tukey-Kramer HSD ConnectingLetters Report	Ordered Differences Report Non-parametric Comparisons withSteel Dwass Method MANOVA	Partial effect size (for 'within-interactions', butnot for 'all between interactions)

All the analyses displayed in Table 5.11 were conducted using one of the three software systems, namely SAS, JMP, and SPSS.

5.5 Results of the Research Investigation

5.5.1 **Testing *RH1_S2*** In this hypothesis it was postulated that there will be a significant difference between the Total Post and Pre, school readiness (mean) scores of the control and chess groups. The first step was to establish whether the ASB scores of both groups improved over time, and therefore whether there was a main within-subjects effect.

A one sample *t*-test indicated that the mean difference between Total Post and Total Pre was statistically significant, $t(115) = 16.458$, $p < 0.0001$*, at a 95 % CL. There is also a correlation of 0.453 and a Cohen's effect size of 1.528, a large effect (larger than 1.00) indicating an improvement in SR scores in matched pairs (one in C group and another in the E group) over time. The table and profile plot (Figure 5.3) below indicate that the ASB scores for the combined groups improved linearly over time.

The Total PRE and POST overall means (LSM) in the profile plot were 40.862 and 59.031. As evident in the plot, both groups showed an improvement in SR scores over the 20-week period. In Table 5.12, a summary of a two-way ANOVA of the within-subjects' effects for time is presented.

Table 5.12

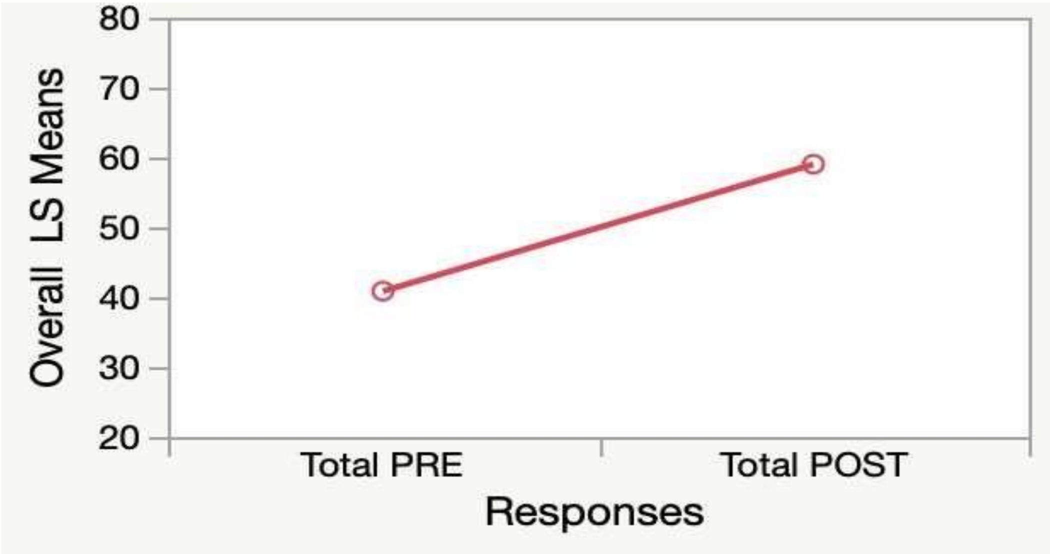
MANOVA summary table: An analysis of groups and time, displaying the within-subjects' effects

Source	Tests	Num DF	Den DF	*F*-ratio	*P*-value
	F test	1	115	270.895	<0.0001*
Within subjects: Time	Univar U. Epsilon	1	115	270.895	<0.0001*
	Univar G-G Epsilon	1	115	270.895	<0.0001*
	Univar H.F. Epsilon	1	115	270.895	<0.0001*

n=115; dependent variable – school readiness; alpha (0.05)

The MANOVA results show that there was a significant improvement in the scores of all the children over time, $F(1,115) = 270.895$, $p < 0.0001$*, at a 95 % CL. The within-subjects' contrasts for time is shown in the profile plot in Figure 5.3.

Figure 5.3



Profile Plot representing improvement in ASB scores of all the learners over time

5.5.2 Testing RH2_S2

(RH2): By the end of the school year, there will be significant differences between the (C) and the (E) groups. The Chess group (CG) will display higher ASB scores/means than the C group, after being exposed to 20 weeks/10 hours of chess tutoring.

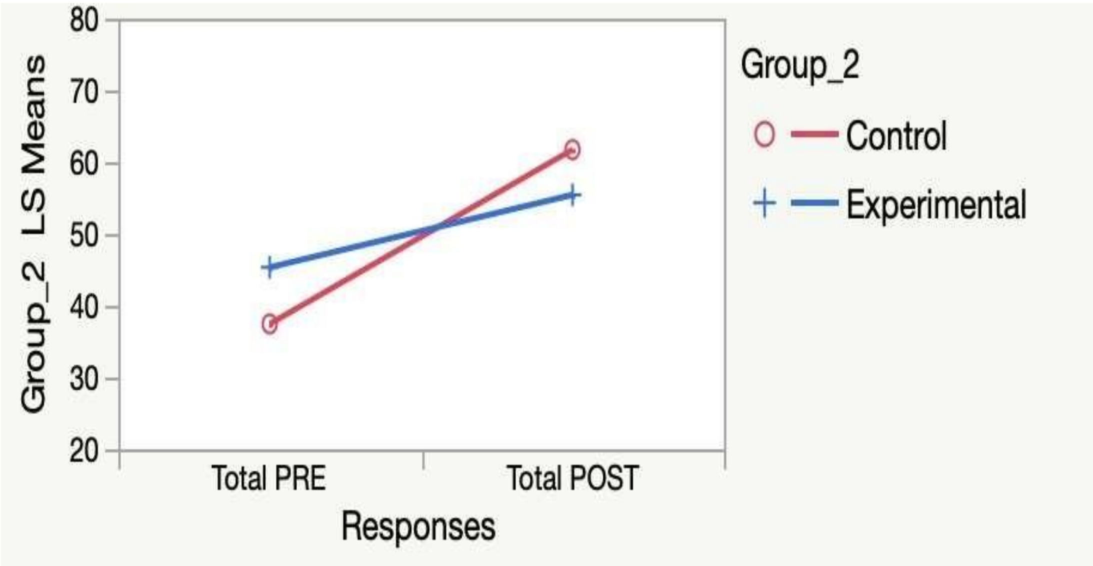
The assumptions required for parametric tests, ANOVA and MANOVA, namely the assumptions of normality, homogeneity, and independence of errors, have been dealt in a previous section. The Levene statistic was greater than the 0.01 AL $F(1,114) = 0.021$, $p = 0.883$,indicating no significance at a 99 % CL and no violation of this equality assumption.

In this research study, it is very important to assess if all the learner-participants as a group have improved over time as tested in the previous hypothesis, RH1 but the aim of this thesis is really to establish and test if there was a statistically significant difference between the mean SR (school readiness) scale points of the two groups (C and E) after exposing the chess group to 10 hours of chess classes during the period of 20 weeks. Even though the SR of both groups improved significantly during the relevant school year, the main research questionis to determine whether there is a relationship between SR and chess tutoring in these schools.

A repeated-measures MANOVA analysis (Table 5.13) and a profile plot indicate that there was a significant difference between the groups. The profile plot (Figure 5.4) displays the LS Means of the DV, SR on the Y-axis of the plot.

Figure 5.4

The Group_2 profile plot from the two-way ANOVA analysis displaying the interaction between the groups and time



The C group: Total PRE 37.462 and POST 61.742, E group: Total PRE 45.35 and POST 55.45. A reversed order of performance is noticeable in the profile plot, with the E group performing better at the first time point, but at the post level, the C group performed remarkably better than the E group. There is also a noticeable linear trend (see also the use of the interval data on continuous data) as well as a possible interaction between groups and time. Table 5.13 displays the MANOVA analysis of these independent variables (groups and time).

Table 5.13

MANOVA summary table: An analysis of groups and time, displaying the within-subjects' effect for time

Source	Tests	Num DF	Den DF	*F* Ratio	*P*-value	Part Eta Sq.
Within subjects: Time	*F* test	1	114	363.901	<0.0001*	.
	Univar unadj. Epsilon	1	114	363.901	<0.0001*	.
	Univar G-G Epsilon	1	114	363.901	<0.0001*	.
	Univar H-F. Epsilon	1	114	363.901	<0.0001*	.
Time by Group_2 Interaction	*F* test	1	114	61.906	<0.0001*	0.351.
	Univar unadj. Epsilon	1	114	61.906	<0.0001*	0.351
	Univar G-G Epsilon	1	114	61.906	<0.0001*	.
	Univar H-F. Epsilon	1	114	61.906	<0.0001*	.

n=116; dependent variable – school readiness; alpha (0.05)

The following conclusions can be drawn from this table. The main effect (or factor) of time (with a sum of square of 5720.407) was significant, $F(1,114) = 363.901$, $p < 0.0001$*, at a 95 % CL indicating a statistically significant difference between the two groups after both groups improved remarkably over a 20-week period.

The *p*-value for the interaction (group_2 by time) is less than alpha 0.05 $F(1,114) = 61.906$, $p = < 0.0001$*, $\eta 2 = 0.351$ [small to medium contribution]), also indicating a significant difference for the interaction term or the combined effect at a 95 % CL. Hence, the suspected interaction between group and time has been confirmed but not in the expected order.

Contrary to the prediction, the chess group did not improve more than the C group after 20 weeks of chess playing but the reverse occurred with the control group outperforming the chessgroup (cf. Figure 5.4).

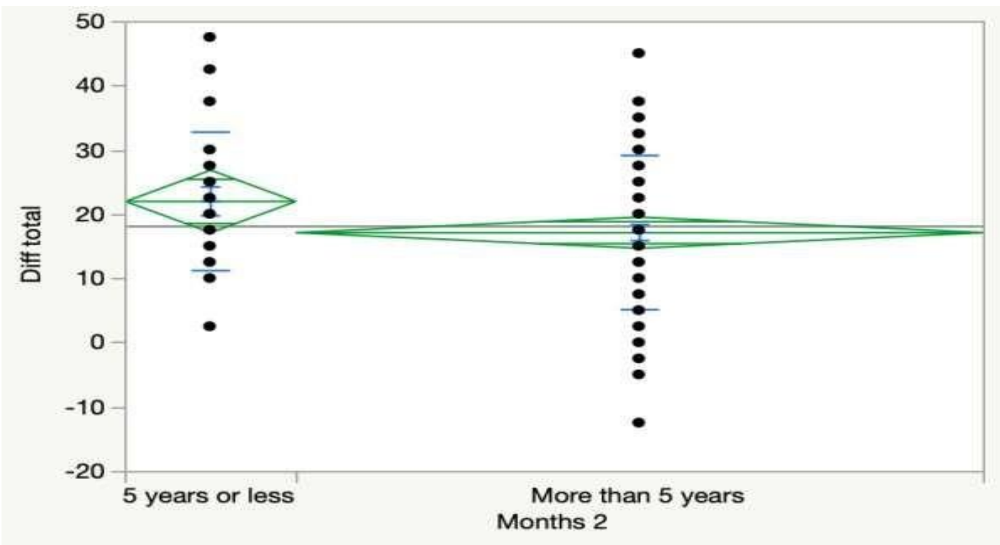
As the hypothesis was not confirmed, no post hoc tests were necessary, and the null hypothesis for the between-groups effect must be accepted. The learner-participants who were exposed to 10 hours of chess classes did not fare significantly better than the group of learners who were not exposed to this treatment.

5.5.3 Testing RH3_S2

A (univariate) one-way repeated-measures ANOVA was conducted to test this research question. The assumptions of normality, homogeneity and independence of errors, have already been dealt with in Section 5.2.1. The Levene and the Brown-Forsythe statistics (both very reliable equality tests) were both greater than the 0.01 AL $F(1,114) = 1.439$, $p = 0.232$ ns and $F(1,114) = 1.794$, $p = 1.183$ ns, indicating no significance at a 99 % CL and no violation of this equality assumption. Figure 5.5 displays the difference between the two groups.

Figure 5.5

One-way Analysis of the Diff total (-4.861) by Months at post level



The diamonds represent the means for:

'-5 years' (*M* 22.065, Std. Dev. 10.763, [17.199 – 26.931/95 %]) and for '+ 5 years' (*M* 17.204, Std. Dev 12.005 [14.785 – 19.624/95 %]), the two age groups at a post level. *N* = 116 (< 5 = 23 +

93 [+ 5 years]).

The testing of RH1 indicated that all the learner-participant levels of SR improved over time, but the experimental group (with chess tutoring as an independent variable) did not fare significantly better than the C group after ten hours of chess classes. An investigation is additionally needed to analyse the post difference (in months at a post level) between the older and the younger age-group to provide an answer to the following question: 'Did the older age group perform significantly better on the ASB test (measuring school preparedness) than the younger age group who are probably still less prepared for school?'

When visually inspecting this graph, it is difficult to detect a difference between these age groups, therefore a Pooled *t-t*est and an *F*-test as part of the ANOVA procedure were employed to determine if there is a significant difference between the older and younger Grade R age groups.

In a null hypothesis, a Pooled *t*-test assumes equal variances with no difference (see the display of *t*-tests in Appendix D [1 – 6]). The *p*-value is greater than an alpha level of 0.05; therefore, there is no significance for a difference of -4.861 (Std Err diff of 2.743), $t(114) = -1.771$, $p = 0.079$ ns, at the 0.95 CL. Subsequently, the *H0* can be accepted of equal variances. In the next section, a one-way analysis was employed to investigate this further.

Table 5.14

Results of One-Way Analysis of Diff total (-4.861) by Months 2 (at a post level)

Source	DF	Sum of Squares	Mean Square	*F*-ratio	*P*-value	Part Eta Sq.
Months_ 2	1	435.702	435.702	3.139	0.079ns	0.026
Error	114	15818.770	138.761			
C. Total	115	16254.472				

Note: 1.R square = 0.026, 2. Adj. R square = 0.018, 3. RMSE = 11.770, alpha (0.05)

The following conclusions can be drawn from Table 5.14:

The Pooled *t* test revealed a non-significant difference (for the Diff = -4.861) between the two age groups at a post level between the + 5 learners and the -5 learners, $t(114) = -1.771$, $p = 0.079$ ns, with a true value between the endpoints -10.295 + 0.573/95 %, indicating equal variances (see Appendix D.5a).

Moreover, a Welch's (ANOVA) *t*-test (testing if means are equal, allowing standard deviations not to be equal) also confirmed a non-significant difference, $t(1,36.731) = 1.891$, $p = 0.066$ ns, at a 95% CL (see Appendix D.5a, b, c and d, for further detail).

In the analysis in Table 5.14, the 'age by category' independent variable was not significant in the ANOVA table, $F(1,114) = 3.139$, $p = 0.079$ ns, at a 95 CL, because the probability value was greater than the 0.5 alpha level. Consequently, it can be concluded that there is not a significant difference between the two age-groups and that the null hypothesis must be accepted. The older learners did not display higher levels of school readiness than the younger learners.

5.5.4 Testing RH4_S2 (RH4)

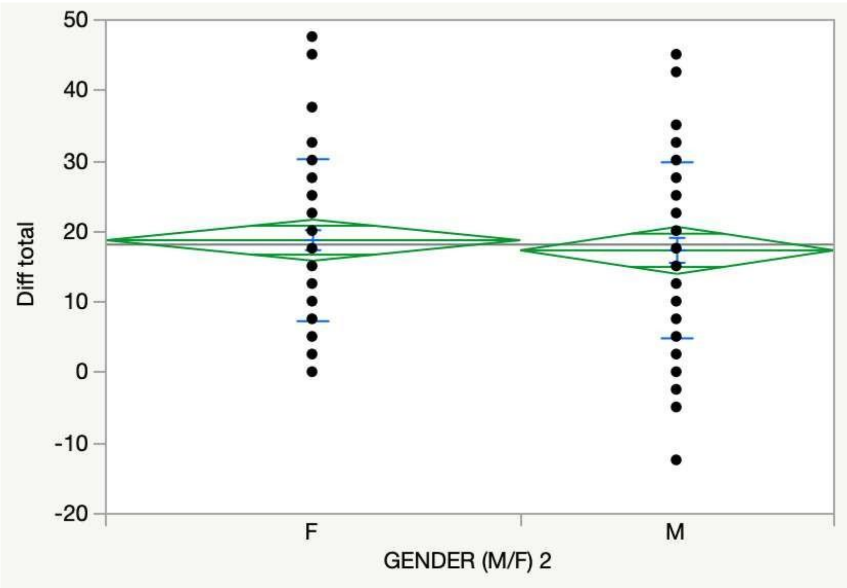
Factors like gender will display a different relation with SR. There will be a significant difference between boys and girls ASB mean scores; the boys will display higher SR scores at the second assessment or time point.

In this study, it is hypothesised that there will be a statistically significant difference between male (boys) and female (girls) learners after being exposed to the Receptive Year programme and additionally the CG, who would have been exposed to chess classes for 10 hours during the period. It is posited that the male participants will display higher scores on the ASB test than the female participants.

The assumptions required for parametric tests ANOVA and MANOVA such as normality, homogeneity and independence of errors were tested and dealt with in the previous section (see Section 5.3.3). No mention was made of outliers but 11 rows were removed. Pertaining to the assumption of equal variances, Levene and the Brown-Forsythe's tests at the post level were both non-significant $F(1,114) = 0.417$, $p = 0.519$ ns and $F(1,114) = 0.241$, $p = 0.624$ ns at a 99%CL. It revealed no significance because the probability values were both greater than the alpha level of 0.01 AL. No other equality tests were significant; therefore, the assumption of equal variances was met, and the *H0* of no significant difference was accepted (see tables in Appendices D [1-6]).

Figure 5.6

One-way Analysis of Variance (of Diff total [-1.437] by Gender [M/F])2



The two genders in Figure 5.6 can be described as follows: the *F* mean = 18.787, with the true value between [15.881 – 21.694/CL 95 %] and the *M* mean = 17.350 with a true value between [14.011 – 20.689/CL 95%]). *N* = 116 (*M* [50] + *F* [66]) participants. A Pooled *t-test*, a Two Sample *t-test*, and an *F*-test (ANOVA) will be employed to determine if there is a significant difference between boys and girls at a post level (see Appendix Tables D [6a – 6d]).

The Pooled *t*-test (Diff of -1.437, Std. Err Diff 2.234), the Two Sample *t-t*est (and Welch *t* test) were not statistically different from zero $t(114) = -0.643$; $p = 0.521$ ns, at the 95 % CL – (5.864 to 2.989/95%). Therefore, the *H0* hypothesis of equal variances must be accepted. The output of the one-way ANOVA is presented in Table 5.15.

Table 5.15

Results of an Analysis of Variance of Diff (-1.437) for Gender (M/F) at a post level

Source	Sum of squares	DF	Mean Square	*F* ratio	*P*-value
Gender (M/F) 2	58.817	1	58.817	0.414	0.521ns
Error	16195.655	114	142.067		
C. Total	16254.472	115			

R square = 0.003, 2. Adj. R square = -0.005, 3. RMSE = 11.19, alpha (0.05)

The following conclusions can be drawn from the data in ANOVA table (5.15):

The *p*-value is greater than the alpha level, therefore there is no significant difference (Difference of -1.437 at a post level) between the two genders, $F(1,114) = 0.414$, $p = 0.521$ ns, at a 95% CL. A Welch (ANOVA) *t* test confirmed the insignificant differences with *t*-(1,100.75) = 0.636, $p = 0.526$ns, at a 95 % CL.

A MANOVA profile plot was construed of the two genders at a post level, see display of the LS Means in the Gender (M/F) profile plot in Figure 5.7.

Figure 5.7

The Gender (M/F)2 (Diff -1437) profile plot from the two-way ANOVA analysis displaying the non-significant interaction between the genders and time

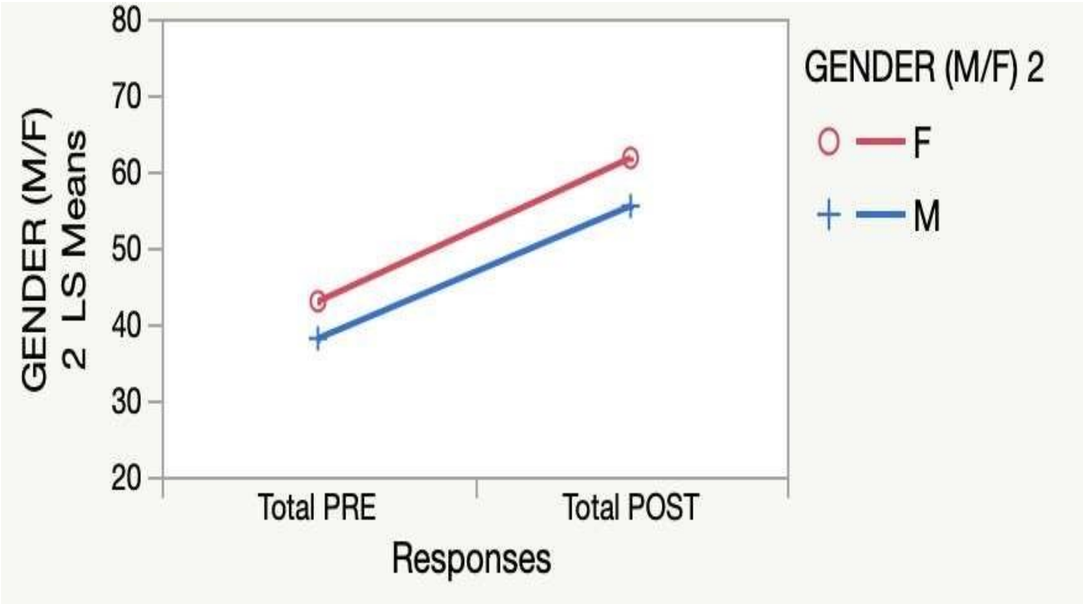


Table 5.16

MANOVA Summary table of the Analysis of gender and time, displaying the within-subjects' effect for time (Diff at post level -1.437)

Source	Test	Num DF	Den DF	*F*-ratio	*p*-value
Within-Subjects: Time	*F*-test	1	114	261.509	< 0.0001*
	Univar unadj. Epsilon	1	114	261.509	< 0.0001*
	Univar G-G Epsilon	1	114	261.509	< 0.0001*
	Univar H.F. Epsilon	1	114	261.509	< 0.0001*
Time*Gender (M/F)2	*F*-test	1	114	0.414	0.521ns
	Univar unadj. Epsilon	1	114	0.414	0.521ns
	Univar G-G Epsilon	1	114	0.414	0.521ns
	Univar H.F. Epsilon	1	114	0.414	0.521ns

N = 116, DV = SR, alpha 0.05

The following conclusions can be drawn from the data in Table 5.16:

The *p*-value is smaller than the 0.05 alpha level, $F(1,114) = 261.509$, $p < 0.0001$*, at a 95 % CL, indicating a significant difference over time and an improvement in levels of SR of both genders. There is a non-significant difference for the interaction term of 'Gender and Time', no combined effect, at a post level, $F(1,114) = 0.414$, $p = 0.521$ ns, at a 95% CL. Hence, there is not an interaction between Time and Gender.

Table 5.17

MANOVA summary table of the analysis of the All Between-Subjects' Effect (Post Diff-1.437)

Source	Test	Num DF	Den DF	*F*-ratio	*p*-value
All Between: Intercept	*F* test	1	114	3269.666	<0. 0001*
GENDER (M/F)2	*F* test	1	114	10.337	0.0017*

The following conclusions can be drawn from the data in Table 5.17.

In Table 5.17 there was a significant difference for the intercept $F(1,114) = 3269.666$, $p < 0.0001$* at a 95 % CI, as well as a significant difference between the two genders $F(1,114)$, = 10.337, $p < 0.001$*, at a 95 % CL (at a post level). The girls' levels of SR improved significantly more over time than the levels of school preparedness of the boys. The time factor subsequently contributed more to this significant difference.

5.5.4.1 Conclusion. With regards to hypothesis RH1, it was found that all the Grade R learners' levels of SR improved statistically over time $F(1,114) = 363.901$**,** $p < 0.001$* at a 95 % CL, interaction, $F(1,114) = 61.906$, $p < 0.0001$* but the chess group did not fare better than the control group, according to RH2, after receiving chess classes over a period of 20 weeks during the period. To explore the relationship between chess instruction and SR as represented by mean scores on the ASB, differences between the male and female gender groups were investigated in Hypothesis 3, by making use of various statistical analyses such as parametric tests, ANOVA and two-way ANOVA, and repetition. Subsequently, the values of the Pooled *t*-

tests (for the gender factor/variable) were not significantly different to zero (for a difference of Diff = -1.437), thereby confirming equal differences (*H0*). Furthermore, pertaining to ANOVA, there was also not a significant difference for gender; $F(1,114) = 414$, $p = 0.521$ ns at the 0.5 alpha-level. However, when a MANOVA was employed, it revealed a significant (in) between-subjects' difference in favour of the female learner-participants, $F(1,114) = 10.337$, $p < 0.001$*, at a 95 % CL).

When variables such as age and gender were explored, significant values were obtained only on the Gender variable (at a post level). The girls displayed higher school readiness scores as represented by the ASB instrument than the boys.

5.5.5 Testing RH5_S2

In the testing of the second hypothesis, RH2, a significant difference between the C (control) and CG (chess) groups was found. The C group (consisting of the Sepedi school) performed significantly better than the E group (consisting of the English and the Setswana schools). All the learner-participants improved over time with respect to their mean ASB scores (the dependent variable) at a post level but the chess group did not display higher mean scores than the control group after 20 weeks of chess classes and there was therefore no statistically significant interaction between time and chess playing. However, it is not yet known which school in the CG performed the best of the two schools; therefore, a one-way ANOVA and parametric tests were used to analyse the data to shed light on this aspect (see Appendix D, D [1- 6]).

The assumptions required for parametric tests, namely Tukey-Kramer HSD, HSD Threshold Matrix and one-way ANOVA, to ensure reliable analyses such as normality, homogeneity, independence of errors and interval data, were tested and are briefly discussed. The data were normally distributed with a positive skewness of 0.047. Outliers were not listed in the Summary Statistics of the distributions noting that eleven rows had been excluded.

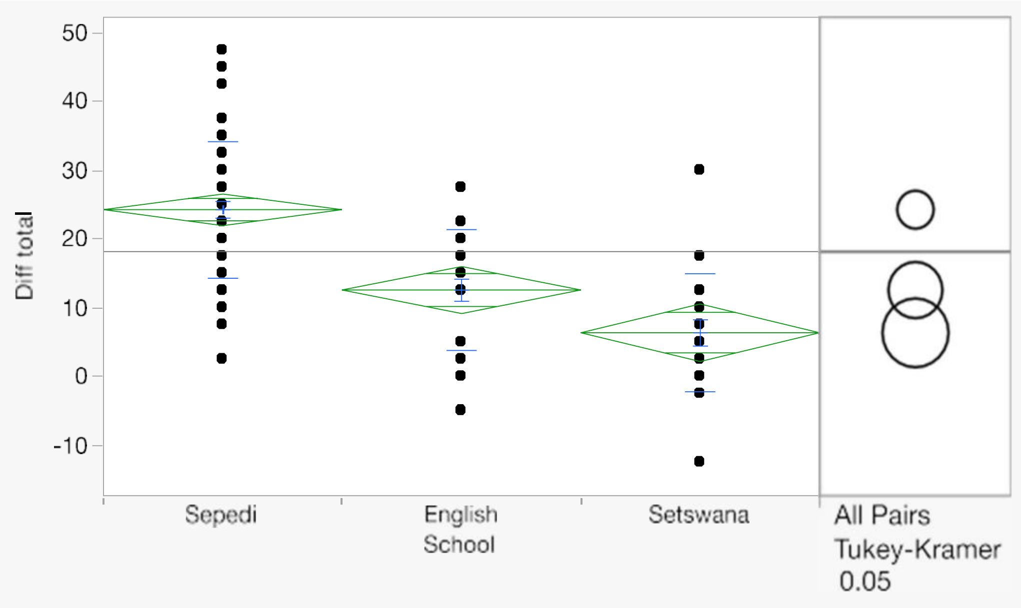
Pertaining to the Levene's test and the other equality tests, the *p*-value for the difference at a post level between the different schools is non-significant $F(2,113) = 0.803$, $p = 0.450$ns at the 99 %CL; hence, there was no violation of this assumption (see Appendix, Tables D[1 – 6] for further detail).

The Levene's test for the difference between teachers in their respective classes at a post level is non-significant, $F(4,111) = 0.920$, $p = 0.454$ ns at the 99 % CL; hence with no violation of this assumption. The ASB psychological test that was used at two time points will allow for independent errors because the correct answers were not discussed with the learners after administering it at the first timepoint. Lastly, in the graphs (Figure 5.8) and in the profile plots in this research investigation, there is evidence of interval data, continuous data, and linearity.

There were no combinations available for analysis; therefore group, school, and teacher(all independent variables) could only be analysed separately. A one-way ANOVA and parametric tests were used to analyse the school group data. This omnibus test was used to determine if there was a significant difference between the mean ASB scores (DV) of the three schools, referring to the Sepedi, English, and Setswana schools in the no-treatment and CG group, at a post level.

Figure 5.8

One-way analysis of Diff total by School (at a post level)



The means (in Diff total) of the three schools represented by the diamonds in the graph, are as follows:

The Sepedi school has an *M* of 24.280 (std dev = 9.939, std. err mean =1.223), with the true value between (21.836 – 26.723 CL 95 %);

- The English school has an *M* of 12.583 (std dev = 8.795, std. err mean = 1.605), with the true value between (9.298 – 15.867 CL 95 %) and
- The Setswana school has an *M* of 6.375 (std dev = 8.6021, std. err mean = 1.923), with the true value between (2.349 – 10.40/CL 95 %), and the sample size *N* = 116 (66 + 30 + 20) for all the learner-participants.

When visually inspecting this graph, it seems as if there could be a statistically significant difference between these three schools but an *F*-test (ANOVA) is still needed to confirm this difference (Table 5.18).

Table 5.18

Results of the analysis of variance (for schools)

Source	DF	Sum of Squares	Mean Square	*F*- ratio	*p*-value	Partial Eta Square
School	2	6182.928	3091.46	34.685	< 0.0001*	0.380
Error	113	10071.544	89.13			
C. Total	115	16254.472				

R square = 0.38; 2. Adj. R square = 0.369, 3. RMSE = 9.44, Obs.: 116; alpha level 0.05

A One-way ANOVA indicates that there were significant differences between the three schools for the School source [*SS* = 6182.928, *MS* = 3091.46] and the Error Source [*SS* = 10071.544 and *MS* =89.13], at the post level $F(2,113) = 34.685$, $p < .0001$*, ɳ2 = 0.38 [with a small to medium contribution of 38 % variance to this difference] at a 95 % CL.

Furthermore, according to tables 5.1 and 5.2, there was also a difference (45.35 - 37.46 = 7.89) between the C and E groups at the pre level with the E group performing the better of the two groups. At the post level, there will probably be a different order of performance.

5.5.5.1 In sum. C Group (All): (Pre) *M* = 37.46; (Post), *M* = 61.74; E Group: (Pre), *M* = 45.35; (Post), *M* = 55.45, For All: (Pre), *M* = 40.36; (Post), *M* = 59.03.

When means comparisons were performed for all the pairs, the Tukey-Kramer HSD test was used with a confidence quantile/q* of 2.375 and a 0.05 alpha level. The absolute Difference minus HSD was calculated in an HSD Threshold Matrix, indicating that positive values show pairs of means that are significantly different. The output of the Connecting Differences Report appears in Table 5.19.

Table 5.19

Connecting Letters report (Schools)

Level	Letter	Mean
Sepedi school	A	24.280
English school	B	12.583
Setswana School	B	6.375

According to this report, levels (schools) are significantly different from one another when they are not connected by the same letter (A or Bs). The Sepedi school ([A], mean 24.280) was significantly different to the English school ([B] mean 12.583) and the Setswana school ([also B], mean 6.375). There was not a significant difference between the English and Setswana schools.

An output from an Ordered Differences Report (Table 5.19), confirmed these results; so, the following conclusions can be drawn:

- There was a statistically significant difference [Diff] (of 17.905, std. err diff = 2.409, with a true value between the two endpoints, [12.182 - 23.628/95%CL] between the Sepedi and the Setswana schools because the probability value $p < 0.0001$ was smaller than the 0.05 alpha level;
- There was also a significant difference [Diff] of 11.696, std. err diff = 2.078, with a true value [6.759 - 16.634/95 % CL] between the Sepedi and the English schools, because the p- value, $p < 0.0001$*, was smaller than the 0.05 alpha level; and the difference [Diff] = 6.208, std. err diff 2.725, $p = 0.063$, [-0.264 – 12.681]95 % CL] between the English and the Setswana schools was not significant. The $p = 0.063$ was greater than the alpha level.

Moreover, the Steel Dwass Method was used to compare all the pairs (usually for non-parametric data), with a confidence quantile/q* of 2.343 and a 0.05 alpha level), and it revealed the following:

- There was not a significant difference between the Setswana and the English schools with a score mean difference of 9.791, std err diff of 4.194, Z value of -2.334, and a Hodges- Lehman value of -7.500, because the *p*- value of $p = 0.05$ns was not smaller than the 0.05 alpha level;
- It was revealed that the English and the Sepedi schools score mean difference was significantly different score mean diff = -29.842, std err. Diff = 6.122, Z = -4.874, Hodges-Lehman - 12.5000, because the probability value was smaller than the 0.05 alpha level, $p < 0.0001$*;
- Both the Setswana and Sepedi schools showed a score mean diff = -35.442, std. err diff. = 6.365, Z value = -5.568, and the Hodges-Lehmann value = -17.5000; and a $p < 0.0001$* at a 95 % CL.

Hence, the Sepedi school (or C group) fared the best at the second time point, followed by the English and Setswana schools (the E group), indicating a reversed order of performance (from a pre to a post level).

5.5.5.2 Conclusion. The null hypothesis (of no improvement in SR in all the Grade R learner-participants in three schools over time) is rejected because the results indicate that, when comparing the Total Diff Post level to the Total Diff at the pre level, there were improvements over a 20-week period in all the schools but more so in the Sepedi school than in the English and Setswana schools.

According to RH1 (the alternative hypothesis), all the learner-participants improved significantly over time. However, an ANOVA analysis $F(2,113) = 34.685$, $p < 0.0001$* ɳ2 = 0.38,at a 95 % CL revealed significant differences between the three schools. This was followed up by parametric tests, which indicated significant differences between the Sepedi, English, and Setswana schools, but not between the Setswana and the English schools. From the pre level to the post level, there was a reversed order of performance, with the Setswana school performing the best at the first timepoint. However, at the second timepoint, the Sepedi school fared the best, followed by the English and Setswana schools. The schools in the experimental group, did not fare significantly better than the school in the control group, after being exposed to 20 weeks of chess classes.

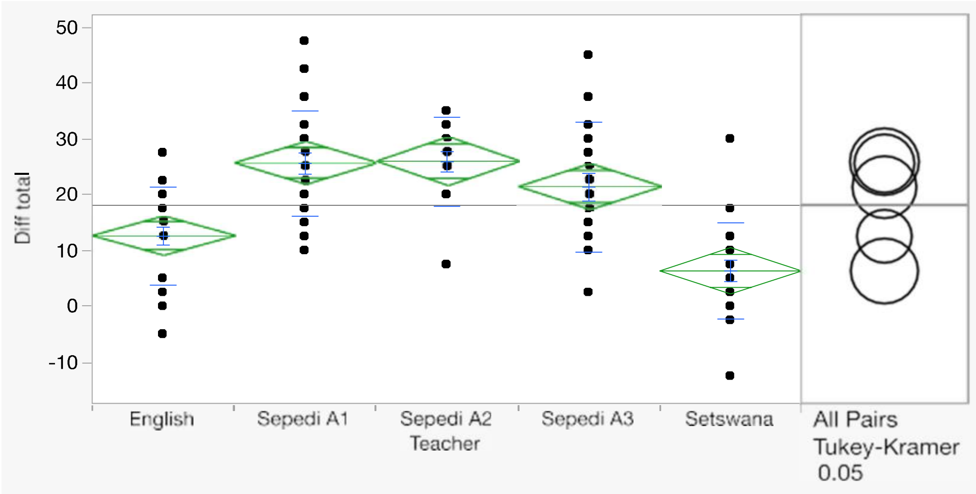
5.5.6 ***Testing the RH5_S2: Teachers***

As indicated in the previous section, the control group (consisting of the Sepedi school, with three Grade R classes: Sepedi A1, A2 and Sepedi A3) achieved significantly better SR scores than the experimental group at the post level. However, at this stage it is not yet known what contribution, if any, the teachers made to this difference, and how the teachers differ from one another. It is therefore also relevant to discover which teacher or educator contributed more to the statistically significant change/improvement in the learner-participants' levels of SR (as reflected on the ASB) over 20 weeks.

The assumptions required for parametric tests, ANOVA and MANOVA, have already been dealt with but are briefly repeated with regard to this analysis (see Appendix D [1 – 6] for further detail). Data were normally distributed, but some outliers were removed. With reference to the equality tests, the Levene's test (and other equality tests) at the post level, were all non-significant (For Levene, $F(4,111) = 0.920$, $p = 0.454$ ns, at a 99 % CL, and for Brown-Forsythe, $F(4,111) = 0.827$, $p = 0.510$, at a 99 % CL). Therefore, the assumption of equal variances was met, and the *H0* of no significant difference, was accepted (see Appendix D [1 – 6]).

Figure 5.9

One-way Analysis of Diff total by Teacher



Note: The diamonds represent different teachers (in classes).

Sepedi A1: *n* = 22, *M* = 21.36 and Std. Dev = 11.642; Sepedi A2: *n* = 25, *M* = 25.6, Std. Dev. = 9.445;

Sepedi A3: *n* = 19, *M* = 25.921, Std. Dev = 8.002; Setswana: *n* = 20, *M* = 6.375, Std. Dev. 8.602;

English: *n* = 30, *M* = 12.583, Std. Dev = 8.795.

The ANOVA test was used to test if there are any statistically significant differences between the five teachers representing the classes they teach. See below the results of the one-way analysis of the difference total (by teachers), where teacher group can be viewed as an independent variable.

Table 5.20

Results of the One-Way Analysis of Diff total by Teachers

Source	DF	Sum of Squares	Mean Squares	*F*- Ratio	*p*-value	Partial Eta Square
Teacher	4	6464.770	1616.19	18.325	.0001*	0.397
Error	111	9789.702	88.20			
C. Total	115	16254.472				

Note: 1. R square (0.397), 2. Adj. R square (0.376), 3. RMSE (9.391), *n* =116; DV = SR; alpha (0.05)

The following conclusions can be drawn based on Table 5.20.

In an ANOVA analysis focusing on the teachers, a significant difference was revealed.

The *p*-value for the teachers (Teacher [*SS* = 6464.770, *MS* = 1616.19], and the [Error *SS* = 9789.792 and *MS* = 88.20]) is smaller than 0.05, $F(4,111) = 18.325$, $p < 0.0001$*, η2 = 0.397 [with a small to medium contribution to this difference] at a 95 % CL. This suggests that there is a significant difference between the teachers.

In the next section the means comparisons for all pairs are discussed. The Tukey-Kramer HSD test was used with a confidence quantile/q* of 2.375 and a 0.05 alpha level. The absolute (Diff) minus HSD was calculated in HSD Threshold Matrix, indicating that positive values show pairs of means that are significantly different. See the output of the Connecting Differences Report (Table 5.21).

Table 5.21

Connecting Letters Report (Teachers and Classes)

Level:	Letter	Mean
Sepedi A2	A	25.921
Sepedi A1	A	25.600
Sepedi A3	A	21.363
English	B	12.583
Setswana	B	6.375

According to this report (Table 5.21), levels (consisting of teachers in classes) are significantly different from one another when they are not connected by the same letter (A or Bs).

All the Sepedi class teachers of (Classes A1-3) shared an A symbol (means varying from 21.363, 25.600 to 25.921) and the Setswana and English class teachers (chess group) shared a ‘B’ symbol (means varying from 6.375 to 12.583), indicating that the two groups were not connected with one another, and were significantly different from one another. There was not a significant difference between the English and the Setswana school teacher, according to this report.

The order of performance was indicated by a one-way ANOVA and by Tukey Kramer HSD post hoc tests, it changed from the first timepoint to the second timepoint (a pre to a post level), as hypothesised in RH5. It is now as follows: 1. Sepedi A2; 2. Sepedi A1, 3. Sepedi A3, 4. English and 5. Setswana teachers**.**

Furthermore, an output from an *Ordered Differences Report,* confirmed the stated results, with the following:

- There was a significant difference [Diff] = 19.546, Std Err Diff = 3.008, with a true *p*-value between [11.202 - 27.889/95%] between Sepedi A2 class teacher and the Setswana teacher because the probability value was smaller than the alpha level 0.05, $p < 0.0001$* at a 95 % CL;
- There was a significant difference [Diff] = 19.225, Std. Err Diff = 2.817, with a true *p*-value between [11.412 - 27.037/95 %] between Sepedi A1 class teacher and the Setswana teacher, because the *p*-value was smaller than the alpha level 0.05, $p < 0.0001$* at a 95 %CL;
- There was a significant difference [Diff] =14.9886, Std. Err. Diff = 2.901, with the true *p* - value between [6.942 -23.034/95 %] between Sepedi A3 and the Setswana class teachers, because the probability value was smaller than the alpha level 0.05, $p < 0.0001$* at a 95 % CL;
- There was a significant difference (Diff = 13.337, std. Err Diff 2.753, with a true *p*-value between 5.701 - 20.973/95 %) between the Sepedi A2 teacher and the English teacher, due to the probability value smaller than the alpha level 0.05, $p < 0.0001$* at a 95 % CL;
- There was a significant difference (Diff = 13.016, std. Err = 2.543, with a true *p*-value between 5.964 and 20.069), between Sepedi A1 teacher and the English teacher,

because the *p*-value was smaller than the alpha level 0.05, $p < 0.0001$* at a 95 % CL; and

- There was a significant difference [Diff] = 8.780, Std. Err. Diff of 2.636, with a true *p*-value between [1.470 and 16.090], between Sepedi A3 and the English teacher, because the *p* - value was smaller than the alpha level 0.05, $p = 0.0101$* at a 95 % CL;

There were no significant differences between the following teachers:

- The English and the Setswana teachers [Diff] = 6.20, std. err diff = 2.711, with a true *p*-value between [-1.309 - 13.726]/95 %], because the *p*-value was greater than the alpha level, *p*=.0.155 ns;
- The Sepedi A2 teacher and the Sepedi A3 teachers [Diff] = 4.557, std. err diff = 2.941, with a true *p*-value between [-3.599 – 12.713/95 %], because the *p*-value was greater than the 0.05 alpha level, $p = 0.532$ ns;
- Sepedi A1 teacher and Sepedi A3 class teacher [Diff] = 4.236, std. err diff = 2745, with a true *p*-value between [-3.376 – 11.849]/95%) because the *p*-value was greater than the 0.05 alpha level, *p* =.0.536 ns; and
- The Sepedi A2 and Sepedi A1 class teachers [Diff] = 0.321, std. err diff = 2.858 with a true *p*-value between [-7.605 – 8.247/95%] because the *p*-value was greater than the 0.05 alpha level, $p = 1.000$ ns.

All the teachers in the control group contributed significantly more to this significant difference in school readiness, at a post level. There were no significant differences between the three Sepedi (A1, A2, A3) class teachers of the C group, as well as no significant difference between the English and Setswana teachers, at a post level.

The non-parametric comparisons for the 'all pairs test' made use of the Steel-Dwass Method ($q^* = 2.727$ and alpha 0.05) and confirmed all the results (of the *Ordered Differences*

Report), except for the Sepedi A3 class teacher and the English teacher. According to this non-parametric comparison test, there was not a significant difference (Score mean Diff = 10.912, std. err diff = 4.234, Z = 2.577, [Hedges Lehmann 7.500], with a true value between 0.000 – 517.500] 95 % CL) between the Sepedi A3 and the English teachers' score mean difference or their performances at a post level, because the *p*-value was greater than the 0.05 alpha level, $p = 0.074$ ns.

In the testing of RH5_S2, a one-way ANOVA, post hoc tests, and non-parametric tests, were employed to investigate possible differences (and increases of SR scores on a ASB test) between the five class teachers, at a post level. A two-way ANOVA with repetition will be used to further investigate differences and relationships in this research investigation (see relevant tables in Appendix D [1 – 6]).

When the two groups and three schools (the Sepedi school in the C group and the English and the Setswana schools in the E group) were indirectly compared with one another over time, in RH1_S2, a significant difference $F(1,114) = 61.906$, $p < 0.0001$*, $\eta2 = 0.351$ at a 95 % CL was found for the Total Post Difference (-14.180, Std. Err Diff = 1.802) between the C and E groups (in favour of the C group, with a reversed order from a pre level to a post level). In a two-way ANOVA with repetition, significant differences were revealed for the time factor $F(1,114) = 363.901$, $p < 0.0001$*, at a 95 % CL and for the interaction between time and group $F(1,114) = 61.906$, $p < 0.0001$*, at a 95 % CL.

In this hypothesis (RH5_S2) a two-way ANOVA will now investigate the time factor (within-subjects' effect) and the (in) between-subjects' effect (referring to the CG group, exposed to chess classes). Subsequently, a researcher would like to know what the effect of the chess classes (the main focus in this research investigation) were on the learner-participant levels of school readiness over a 20-week period, in Grade R in historically disadvantaged schools.

A MANOVA Fit Response specification is now provided to construct the linear combinations across responses. After eleven rows have been removed, the *N* was 116, with 111DFE.

Table 5.22

Parameter estimates

Level	Total Pre	Total Post
Intercept	40.830	59.199
Teacher Sepedi A1	-1.530	5.700
Setswana	8.294	3.699
English	2.002	-3.782
Sepedi A2	-2.935	4.616

Figure 5.10

The *Teacher profile plot from the two-way ANOVA analysis displaying the interaction between the groups and time*

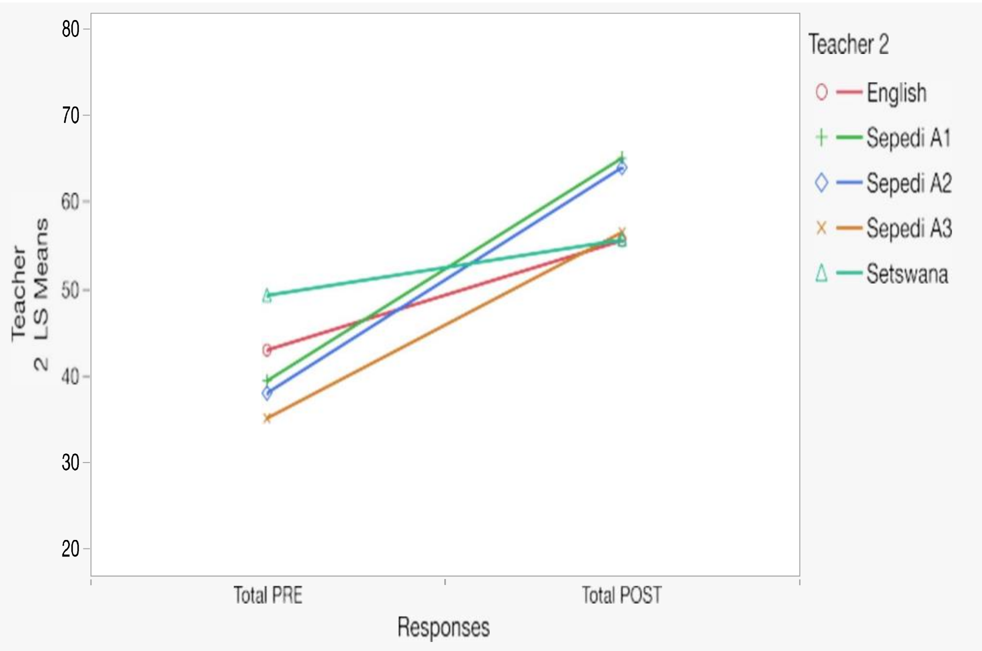


Table 5.23

Estimates Parameter

Classes	Pre: Order of performance	Total Pre	Post: Order of performance	Total Post
Sepedi A2	3	39.300	1	64.9
Setswana	1	49.125	4	55.5
English	2	42.833	5	55.416
Sepedi A1	4	37.894	2	63.815
Sepedi A3	5	35	3	56.363

In Table 5.24, a two-way ANOVA summary of the within-subjects' effects and the interaction term are presented.

Table 5.24

MANOVA Summary of the Within-subjects' (Teachers and Time) Effects and the Interaction term

Source	Tests	Exact F	Num DF	Den DF	*p*-value	Part Eta Sq.
Time	*F*-test	431.946	1	111	<.0001*	
	Univar unadjusted Epsilon	431.946	1	111	<.0001*	
	Univar G-G Epsilon	431.946	1	111	<.0001*	
	Univar H.F. Epsilon	431.946	1	111	<.0001*	
Time* Teacher	*F*-test	18.325	4	111	<.0001*	0.397
	Univar unadjusted Epsilon	18.325	4	111	<.0001*	0.397
	Univar G-G Epsilon	18.325	4	111	<.0001*	0.397
	Univar H.F. Epsilon	8.325	4	111	<.0001*	0.397

*Dependent Variable = School-readiness, alpha (0.05)

The following conclusions can be drawn from Table 5.24.

There was a significant difference $F(1,114) = 431.946$, $p < 0.0001$*, at a 95 % CL for the main factor of time. All the learners (as indirectly reflected on teachers' performances) improved over time as evidenced in the learners' SR mean scores at a post level. There was also a significant difference $F(4,111) = 18.325$, $p < 0.0001$*, $\eta 2 = 0.397$ [small to medium contribution, at a 95 %CL for the combined effect of teachers and time. All the SR mean scores of the teachers and the classes improved significantly over 20 weeks.

Therefore, the null hypothesis cannot be accepted, due to the significant results of the within-subjects' effect of teachers. All the teachers (and/or their respective classes) displayed significant improvements (as represented by scores on the Global aptitude scale) over the 20-weekperiod during the relevant school year, thereby confirming a relation between SR and time (see Section 2.8).

5.6 Summary of Findings Relating to Stage 2 of the Research

5.6.1 RH1_S2

The participants in three schools were exposed to a Grade R Receptive programme. A repeated-measures of analysis indicated that the SR scores of both groups improved significantly over time (main) factor, $F(1,114) = 363.901$, $p < 0.0001$*, at a 95 % CL. Hence, both groups improved with a statistical significance over time (20 weeks). The ASB mean scores of both groups were significantly higher than their pre-test scores as measured on this instrument. Therefore, the directional hypothesis must be accepted, and not the null hypothesis of zero difference.

All the teachers (or learners) in the classes improved significantly over time, $F(1,111) = 431.946$, $p < 0.0001$*, at a 95 % CI; with a statistically significant interaction between time and the teacher group, $F(4,111) = 18.325$, $p < 0.000$*, at a 95 % CL.

All the learners in the two (-5 and +5) age groups, improved significantly over time, $F(1,114) = 80.700$, $p < 0.0001$*; 95 % CI, but no interaction took place between the time and age variables/factors, and the older learners did not perform significantly better than the younger learners. The probability value for the interaction term was greater than the 0.05 alpha level, $F(1,114) = 3.139$, $p = 0.079$ ns, at a 95 % CL.

Lastly, all the learners in the two gender categories (boys or girls) improved significantly more over time, $F(1,114) = 261.509$, $p < 0.0001$*, at 95 % CI. There was no interaction between time and the gender variable/factor and the probability value was greater than the 0.05 alpha level, $F(1,114) = 0.414$, $p = 0.521$ ns, at a 95 % CL.

5.6.2 RH2_S2

At the end of the school year there was a significant difference between the control and the experimental groups. A pooled *t*-test, $t(114) = -7.868$, $p < 0.0001$*, at a 95 % CL, revealed a significant difference (Diff -14.180) between the experimental and control groups (see Appendix D [1 – 6] for further detail).

Furthermore, an Analysis of Variance of the two groups also revealed that there was a significant difference between the two groups at a post level, $F(1,114) = 61.906$, $p < 0.0001$*, $\eta 2 = 0.351$ [small to medium contribution to this difference], at a 95% CL. The group by time effect was significant but favouring the control group and not the chess group. It was hypothesised that the chess or treatment group will display higher ASB scores than the controlgroup after exposure to chess classes but evidently this was not the case. The null hypothesis must therefore be accepted.

5.6.3 RH3_S2

In this research investigation the Pooled *t* test revealed no significant difference (for the Diff = -4.861) between the two age groups at a post level (between the + 5 learners and the -5 learners), $t(114) = -1.771$, $p = 0.079$ ns, with a true value between the endpoints - 10.295 + 0.573/95 %, indicating equal variances. Moreover, the 'age by category' independent variable was not significant in the ANOVA table, $F(1,114) = 3.139$, $p = 0.079$ ns, at a 95% CL, because the probability value was greater than the 0.5 alpha level. Consequently, there was not a significant difference between the two age groups. This non-significant difference was confirmed by the Welch *t* test, $t(1,36.731) = 1.891$, $p = 0.066$ ns (see Appendix D.5b for further detail).

The output of the two-way ANOVA analysis with repetition revealed the following: both age groups developed significantly over time, $F(1,114) = 80.700$, $p < 0.0001$* at a 95% CL, thus contributing mainly to the (main) time factor (of improvement in SR levels over time). There was not a significant interaction between time and age, $F(1,114) = 3.139$, $p = 0.079$ ns, and there was also not a significant difference (or an in between-factor), $F(1,114) = 2.924$, $p = 0.090$ ns at a 95% CL, none of the groups performed significantly better than the other. The older learners did not display higher levels of school readiness than the younger learners, therefore the null hypothesis was accepted.

5.6.4 RH4_S2

In order, to explore the relationship between chess instruction and SR (as represented by mean scores on the ASB), differences between the male and female gender groups were investigated by employing different tests and analyses. In hypothesis RH1, it was found that the learners in both groups improved significantly over time, $F(1,114) = 61.906$, $p < 0.0001$*, at a 95% CL, which indirectly included the boys and girls.

The values of the Pooled *t*-test (for the gender factor/variable) were not significantly different to zero (for a difference of Diff = -1.437), $t(114) = -0.643$, $p = 0.521$ns, at the 95% CL, thereby confirming equal differences (*H0*). Furthermore, pertaining to ANOVA, there was also not a significant difference for gender; $F(1,114) = 0.414$, $p = 0.521$ ns at the 95% CL (see Appendix D [1 – 6] for further detail.

A two-way ANOVA (with repetition) was employed and revealed that the two gender categories (boys or girls) improved significantly over time, $F(1,114) = 261.509$, $p < 0.0001$*, at 95% CL. However, there was no interaction between the time and gender variables/factors because the probability value was greater than the 0.05 alpha level, $F(1,114) = 0.414$, $p = 0.521$ns, at a 95% CL. However, there was a significant difference for the (in)-between (gender) subjects' effect (at a post level), $F(1,114) = 10.337$, $p < 0.001$*, indicating that the girls performed significantly better than the boys on the ASB test at the end of the time interval (see relevant tables in Appendix D[1 – 6], for further detail).

The boys did not display higher SR scores at the second time point and therefore the null hypothesis can be accepted.

5.6.5 RH5_S2

5.6.5.1 Schools. On average, an ANOVA analysis revealed significant differences between the three schools $F(2,113) = 34.685$, $p < 0.0001$* $\eta 2 = 0.38$ [a small to medium contribution to this difference), at a 95% CL. This was followed up by parametric tests (Tukey-Kramer HSD and HSD Threshold Matrix, Ordered Difference Report, and a non-parametric comparisons test forall pairs (by using a Steel-Dwass method) which indicated significant differences between the Sepedi, English and Setswana schools but not between the Setswana and the English schools. From the pre level to the post level, there was a reversed order of performance. The Setswana school performed the best at the first timepoint but the Sepedi school fared the best at the second timepoint, followed by the English and Setswana schools.

Hence, the schools in the treatment group, did not fare significantly better than the Sepedi school in the control group, after the chess group was exposed to 10 hours of chess classes.

To summarise, there were significant differences amongst participants in the three schools (as hypothesised), with a different order of performance in the schools (as hypothesised), from the pre to post level. The two (English and Setswana) schools in the treatment group did not fare significantly better than the Sepedi school in the control group. Therefore, the null hypothesis must be accepted for the two schools in the treatment group, who did not perform better than the control group/school at a post level.

5.6.5.2 Teachers. In RH5_S2, a two-way ANOVA with repetition was used to assess the within-subjects' effect of the teachers' performance (over time). A significant difference was revealed when the *p*-value was smaller than the 0.05 alpha level, $F(1,111) = 431.946$, $p < 0.0001$*, at a 95% CL. The interaction between 'teacher and time' was also significant, $F(4,111) = 18.325$, $p < 0.0001$*, at a 95% CL, as revealed in an Analysis of Variance. A significant difference between the teachers or classes was found (as evidenced on the learners-participants ASB mean scores) with a different 'order of performance' between the teachers and classes (from a pre to post level). All the teachers (where 'teacher' represents the children in the class they teach) improved significantly over time during the period but not at the same rate.

Means comparisons for all pairs were done, by making use of Tukey-Kramer HSD (the confidence quantile was 2.77 and alpha 0.05). A *Connecting Letters Report* revealed that the three teachers in the Sepedi classes (in the C group) were significantly different from the teachers in the English and Setswana classes (the experimental group). This was confirmed by the non-parametric comparisons for all pairs test (by making use of a Steel-Dwass method). There were significant differences between the Sepedi A 1-3 class teachers and the English and Setswana teachers. A two-way ANOVA with repetition was used to further investigate a possible difference between teachers, but not a significant difference for the (in) between-subjects' effect, $F(4,11) = 1.848$, $p = 0.124$ ns, at a 95 % CL was found. The probability value was greater than the 0.05 alpha level adopted in this research.

5.7 General Conclusion

Outcomes from RH2_S2, revealed that in spite of an improvement in the participants' SR levels, the Treatment or E group did not fare statistically significantly better than the C group who were not exposed to chess classes at a post level, $F(1,114) = 0.194$, $p = 0.660$ ns, at a 95 % CL. Moreover, at a post level, there was not a significant difference between the teacher groups, $F(4,11) = 1.848$, $p = 0.124$ ns, at a 95 % CL.

Subsequently, there was a significant difference between the control and experimental groups, favouring the control group, $F(4,11) = 1.848$, $p = 0.124$ ns, at a 95% CL. (The intercept was significant, $F(4,11) = 3145.951$, $p < 0.0001$*, at a 95 % confidence interval) (see tables in Appendix D [1 – 6] for further detail).

There were significant differences amongst the participants in the relevant classes and teachers in the current investigation. There was a different order of performance between the different teachers and classes at a post level. The teachers in the Sepedi classes performed significantly better than the Setswana and English teachers, though this was not confirmed by the two-way ANOVA output. The two classes in the treatment group did not significantly improve more than the classes in the control group (but it was not hypothesised). Subsequently the null hypothesis for RH5 (between-subjects) was accepted as there was no significant difference between chess instruction and school readiness scores of Grade R learners. All the teachers and the learners improved significantly during the year, as evidenced in the school-readiness scores of the ASB test.

Chapter 6

Discussions, Conclusions, Recommendations

In this chapter, the contributions made by the research in the two stages are discussed and the implications of the results obtained are considered. To restate, the objective of the study was to investigate the relationship between chess instruction and the development of cognition and intelligence by using a sample (*N*=64) of young children in a standard Quintile 5 public school and a sample (*N*=116) of children from three developmental Section 21 schools in poverty-stricken areas in Gauteng. Hence, the research focus fell on teaching chess as an educational tool while the research was applied to young children in different school environments in two research studies.

Both studies are situated in the theoretical framework of research on the novice-expert shift in cognitive psychology (see Anderson, 1990, 1996; De Groot, 1946; 1978; Persky & Robinson, 2017; see also Section 2.1). In the light of this theory, it was postulated that chess instruction or chess playing would confer a cognitive benefit on the Grade R learners receiving such instruction over a certain period, in this case, 20 to 40 weeks. It was posited that they would score better in psychometric tests (Sections 4.1.1; 4.1.2) than learners who did not receive similar exposure to chess instruction when tested using the JSAIS scales in the first stage of the research (S1) and the ASB in the second stage of the research (S2). It was further hypothesised that some effect owing to the treatment factor (i.e., the chess instruction) in S1 and S2 would be manifested after reasonably short periods during which the experimental groups participated in playing the game based on instruction in chess even though this instruction involved different methods, it was presented by different trainers (teachers who received chess training and a chess facilitator) and in different schools or educational environments, in the two stages of research.

The results of Stage 1 are first discussed, and thereafter, the results yielded by Stage 2 are discussed and interpreted.

6.1 Discussion of the Hypotheses in the First Stage of the Research

Four different research hypotheses were postulated in this part of the research; they are dealt with in turn.

6.1.1 Research Hypothesis (RH1-S1): The Within-Subjects Development in GIQ during the Research Period

In RH1_S1, in the first hypothesis, a difference in the mean scores of both groups at the pre and post time points had to be obtained to imply an improvement in the GIQ mean scores in the time interval. This was actually a precondition for continuing with the other research questions because, if there was no normal development in intelligence and scholastic performance affecting the whole group of children over the period, there would be no point in continuing with the other research questions focusing on group differences. It was expected that there would be an improvement in the scholastic testing scores and that this can be attributed to normal improvement in scholastic and cognitive abilities by both groups over the period. It is ideal if there are no large differences between two groups at a pre level, but small differences between groups mean scores, are not problematic. A multivariate repeated measures-analysis of variance revealed a significant (main) within-subjects' effect for time, $F(1,62) = 94.064$, $p < 0.000$* at a 95 % Confidence Level; with a large contribution of 61% variance to GIQ (eta square is .611).

The first hypothesis, H1_S1, was therefore supported because the JSAIS test scores of both groups improved significantly over the period. Thus, cognitive development evidently did occur in all the children (i.e., in both the control and the treatment groups) in this sample during the 40-week interval of time; this can be ascribed to normal cognitive and biological maturation as proposed by Gesell (1940), Inhelder and Piaget (1958), Bruer (1999) and Gottfredson (1997).

However, the educational environment provided by the Grade R preparatory school could also have had a facilitating effect. Children attending a Quintile 5 standard preparatory school have access to an enriching environment involving, inter alia, books, educational toys, climbing frames, additional computer classes, television sets, class outings, and extra mural activities (Mergendollar et al., 1990). Grade R learners follow the prescribed CAPS curriculum that can remove some of the characteristics that vary among children stemming from different levels of exposure to relevant environmental stimuli at home, that is, the nurture effects relating to neural and genetic factors that were discussed in Sections 2.1 – 2.2.2).

Due to the type of methodology employed in this study, which was based on a convenience sample and no randomisation, no valid inferences can be made about the specific contribution yielded by the Grade R environment. Therefore, the role and influence of the school system on the cognitive improvement of the children (the within-subjects' effect) cannot be determined in any detail.

6.1.2 Research Hypothesis RH2_S1: Results Relating to the Interaction Between Group and Time

In Stage 1 of the research, the six-year-old participants were exposed to 20 hours of chess with the researcher acting as the experienced chess instructor, Grade R chess curriculum writer and psychometrist. It was postulated that there will be an interaction between group and time, and that the Global Intelligence Quotient scores of the chess treatment group would improve significantly more than those of the control group. A repeated-measures ANOVA analysis revealed that there was a non-significant difference in the GIQ scores of the two groups at the pre level $F(1,62) = 0.142$, $p = 0.707$ ns at a 95 % CL. The mean GIQ score for both groups C (pre: 102.1; post: 106.87) and E (pre: 101.118, post: 109.118) clearly improved over the period and the repeated measures ANOVA analysis indicated that the improvement in the GIQ scores for both groups over this period were significant, [C] F(1,62 = 25.69, $p < 0.000$* and [E] $F(1,62) = 81.23$, $p < 0.000$*, at a 95 % CL.

In addition, the 'Group * Time' interaction was found to be significant $F(1,62) = 6.296$, $p = 0.015$*, at a 95 % CL, although the effect size was small (eta = 0.095), implying that only 9.5 % variance is due to the time by group interaction. Nonetheless, this hypothesis (RH1_S1) was supported by the data because there was a statistically significant interaction between time and group, and the treatment group improved significantly more than the control group did over the period, as predicted. This interaction is also clearly illustrated in Figure 6.2 which indicated that although the C group initially had a slightly higher mean than the treatment group, the E group ended with higher means at the final time point.

The impact that chess seems to have exerted on scholastic performance and general intelligence cognition (GIQ) in this study fits current theory and research about the possible link between chess and cognition (Ericsson, 1988; Scholz et al., 2008). Some researchers believe that learning is better when presented with visual information than with auditory information, as in chess playing (Schneck, 2005, p. 420).

Thus, according to Milat (1997), chess playing can be regarded as the link between the abstract symbolic and visuospatial thinking required in mathematics (McDougall, 2013, October 8). Evidently, some transfer between chess training and cognition occurred in this stage of the research but the effect was small. These significant results and/or interactions between group and time in S1, is supported by chess expertise theories and Deliberate practice (see Sections 2.1.2; 2.1.3), as well as findings in research studies. As noted, the number of studies on young children, is not sufficient, therefore studies in higher grades are also mentioned. The following research studies support the findings in H2_S1: Fried and Ginsburg, (n.d.)., Frydman and Lynn (1992), Gliga and Flesner, (2014), Karakaş (2023), Luneta and Giannopoulus (2016), Sallon

(2013), and Sigirtmac (2012) when they investigated different skills. Jerrim et al. (2018) and Pells (2016) did not support the findings. In a meta-analysis, researchers (Jerrim et al., 2018), in a randomised controlled trial, found no evidence that chess instruction improved the math ability of children. Sala and Gobet (2016; 2017) believed that chess groups, included and re-examined in a meta-analysis, performed better because they made use of poor designs. Furthermore, in this study/meta-analysis, there were no significant differences in math problem-solving or metacognitive abilities in a post test. Sala and Gobet maintained that the participants could also have acquired general cognitive skills, namely concentration (as in Scholz et al., 2008) and intelligence, which would positively affect their mathematical abilities. In the Pells (2016) study, no improvement was observed after learners were exposed to chess classes, hence the researchers found that chess playing did not make children cleverer.

The relatively small effect size obtained in this study is not surprising because there is still an ongoing critical debate whether positive transfer from chess playing to other school subjects and general cognitive abilities does really take place, as discussed in chapters 2 and 3 (see Sections 3.7.2 – 3.7.3), where theories about the acquisition of chess expertise and Ericsson's theory of deliberate practice (1988) are described (see Section 2.1).

6.1.3 Results Relating to the RH3_S1 Between Groups and Gender Over Time

In RH3_S1, a two-way repeated-measures ANOVA revealed that there was not a significant effect of time on gender $F(1,62) = 0.028$, $p < 0.713$ at a 95%CL, and no significant interaction between gender and group over time $F(1,62) = 0.384$, $p = 0.538$ ns. Thus, this hypothesis was not supported and the null hypothesis must be accepted because there was not a statistically significant difference between the scores of the boys and the girls after the 40 weeks of chess instruction, as predicted.

Males and females display many differences while they are still developing, especially when they are young, as evidenced in studies conducted by Adani and Cepanec (2019) and Ananthaswamy and Douglas (2018) but, in this research study no significant differences were found between either their intelligence development over the period or the effect of chess on this development (see also Aciego et al., 2012; Chitiyo et al., 2023; Reilly et al., 1978).

Furthermore, there are some indications in the literature that there are different patterns of development that affect young boys and girls (Sections 3.1.1.4 – 3.2), with young girls developing slightly better verbal skills in the early stages of cognitive development and young boys showing a slight advantage in numerical and performance skills (Carlton & Winsler, 1999). No such differences were found in this stage of the research study. There were no significant differences in any of the subscales that could be attributed to gender per se, and this hypothesis was therefore not supported. In a study conducted by Reilly et al. (2022), self-estimated intelligence and observed intelligence of males and females was explored. Hence, a pattern of systematic underestimation (of their own intelligence) in females was found, plus hierarchical multiple regression showed significant independent effects of gender, masculinity, and self-esteem differences. There were also no significant differences in motor development between males and females, relevant in being 'school ready or not' decades ago (Carlton & Winsler, 1999), when boys were considered to be more active. Furthermore, according to studies conducted by Bruwer (2014) and Van Rensburg (2015), the majority of the Grade 1 learners, both boys and girls, who they assessed were still not school ready when entering formal school years.

6.1.4 Results Relating to the Fourth Research Hypothesis of Stage 1 (RH4_S1)

The Group by Time interaction was found to be significant in Stage 1 as the mean GIQ score for the C and E groups displayed significant differences across time as discussed in section 5.2.3.

Further investigation pertaining to the contribution of the PIQ, VIQ, and numeric subscales of the JSAIS to the group by time effect reflected in the GIQ scores revealed that the only statistically significant difference between group and time was associated with the Performance-Intelligence-Quotient (PIQ) subscale. The repeated-measures ANOVA indicated that there was a significant difference between the development of the groups over time with regards to the performance subscale, PIQ, and $F(1,62) = 4.148$, $p = 0.046$, at a 95 % CI but the effect size was small (eta square = 0.063).

The main findings emanating from this phase (S1) of the research is therefore that the chess instruction exerted a small effect on global intelligence, and this effect is mostly due to a slightly greater improvement in the performance or fluid intelligence of the chess groups relative to the control group (Frydman & Lynn, 1992; Waters et al., 2002). Thus, the results revealed statistically significant differences between the group means of the Performance Intelligence subscale (PIQ) at a 95 % confidence interval, PIQ], $F(1,62) = 4.15$, $p = 0.046$* as well as general intelligence, [GIQ], $F(1,62) = 6.25$, $p = 0.015$*, which indicates a relation (interaction) between chess instruction over (40 weeks) time and intelligence. The magnitude of the relation (partial eta square = 0.063) was small, with the time factor (and not the chess factor) contributing more to this combined effect.

Chess playing is a strongly visuospatial skill which requires the ability to mentally contemplate dynamic changes on a chess board where various possible moves must be considered, and their results of the game calculated (see also Bocchi, et al., 2024; Fine, 1965;

Saariluoma, 1992). In the light of this visuospatial nature of the game, it was hypothesised that learning to play chess will produce a positive effect on the chess group's cognitive development and scholastic testing at the end of the 40-week period. Support for this prediction was found. The PIQ test scores of the chess group increased significantly more than those of the control group between the first to second time points. It is possible that chess playing could facilitate various other aspects of human cognition and learning but, in this study, it seems to have had an effect only on the performance subscale PIQ that measures fluid intelligence. However, it should be noted that fluid intelligence also affects other skills such as attention and working memory, as discussed in section 2.4.3 and 2.4.4, and that it is therefore an important aspect of cognition.

The research conducted in Stage 1 did confirm that chess classes may confer a slight cognitive benefit for young children but the effect was mainly restricted to the visuospatial and performance dimension of cognition and, as already mentioned, the effect size was small. It should also be noted that this was not a true experimental study but rather, a quasi-experimental research study because there was no random allocation of participants to the two groups as required for completely valid experimental research (Gobet & Campitelli, 2007; Gobet & Sala, 2023; Trinchera & Sala, 2016). As a result, other factors could also have contributed to the observed difference between the groups in the PIQ scores, for example, a slight bias in the group selection and an interest and perhaps aptitude for board games by the chess group that may have helped to differentiate between them and the control group in terms of visuospatial intelligence, as well as motivation by the researcher, as trainer and assessment practitioner. However, the two groups did test the same in the JSAIS scale in the pre-condition, so there were no significant group differences on the JSAIS scale when the chess classes began. It therefore seems reasonable to conclude that the chess intervention did have at least a small effect on the subsequent statistically significant differences between the two groups on the PIQ subscale when the JSAIS test was administered at the end of the period. The learners in the treatment group acquired/learnt quite an amount of chess knowledge during the period (De Corte, 2003). In any case, the small positive effect of chess on fluid intelligence and early visuo-spatial cognitive development is consistent with the current state of research on the influence of chess on scholastic performance as suggested by, for example, Sala and Gobet (2017), in a meta-analysis, and a study conducted by Christiaen and Verhofstad-Denève (1981). These researchers reported that fifth graders in an experimental group, were exposed to (2 years') chess playing, and thereafter they performed significantly better on Piagetian tasks, school tests, and standardised tests than the control group. Hence these results in the studies are supported by the cognitive development theory of Inhelder and Piaget (1958), which continues through various stages. Waters et al. (2002) and Djakow et al. (1927), though, did not support a close relation between visuospatial skills and chess practice in chess players. Waters et al. (2002) did not support studies that revealed significant correlations between chess skill and performances on some psychometric tests, namely a performance IO (as in the PIQ). This was the case, because these researchers found that the perceptual skills of chess players did not generalise to visual memory of shapes in their study. Furthermore, Grabner, et al, (2007) found a significant positive correlation between a full or global scale Intelligence Quotient, and chess rating, in slightly older children. Presently, researchers believe that visuospatial abilities/skills can be regarded as important when children are young but not in adulthood (Gobet, 2016; 2017).

In the next section, the research hypotheses of stage 2 are discussed.

6.2 Discussion of Stage 2 of the Research

The first stage of the research served as a type of proof of concept and established that chess could have an effect on scholastic and cognitive development in reasonably ideal circumstances or environments. Most of the salient nuisance variables were controlled for in this part of the research because the groups were drawn from a single socio-economic area, and all the children were in the same school system.

The second stage was much more exploratory in nature than the first stage, because the idea was to investigate the practical application of chess in a non-standard developmental context where the school system, environmental context, cultural variables, teachers, and language could all play a role. Three different schools were used in this stage, one of which functioned as a control group, and the other two schools were designated to be the treatment group or condition, where chess classes were presented to the children.

6.2.1 H1: Within-Subjects' Effects

Results relating to the Within-Subjects' Effects in the First Hypothesis of Stage 2 (RH1_S2) are discussed in this section.

Learner-participants in three schools were exposed to a Grade R Receptive programme in this current study. The repeated-measures ANOVA that was performed indicate that the school readiness (SR) scores of both groups increased significantly during the period, $F(1,114)$ = 363.901, $p < 0.0001$*, at a 95 % CL [15.981, 20.354]. The SR test scores of both groups thus reflected a significant increase over the 20 weeks on the general aptitude for school beginners (ASB) scale as expected. There was a significant Group by Time interaction $F(1,114) = 61.906$, $p < 0.001$*, eta = 0.35 at a 95 % CL [15.981, 20.354], with a small contribution of 35% of variance to the time factor.

All the learners in the different teacher groups in the different classes improved significantly over time, $F(1,111) = 431.946$, $p < 0.0001$*, at a 95 % CI [2.349, 29.777], and there was a statistically significant interaction between time and teacher group $F(4,111) = 18.325$, $p < 0.000$*, at a 95 % CI [2.349, 29.777].

The learners in the two (-5 and +5) age groups also improved significantly over time $F(1,114) = 80.700$, $p < 0.0001$*; 95 % CL [-10.295, 0.573] but there was no interaction between the time and age factors, and the older learners did not test significantly better than the younger learners. The probability value for the interaction term was greater than the 0.05 alpha level $F(1,114) = 3.139$, $p = 0.079$ ns, at a 95 % CL [-10.295, 0.573]. Lastly, the learners in both the two-gender categories (boys or girls) improved significantly over time, $F(1,114) = 261.509$, $p < 0.0001$*, at 95 % CI [-5.864, 2.989] but there was no interaction between the time and the gender factors, $F(1,114) = 0.414$, $p = 0.521$ ns, at a 95 % CL [-5.864, 2.989].

Setswana class in the chess group did better than the other groups in the first assessment but one of the Sepedi classes in the C group performed the best in the second assessment. This cognitive development over time (in S1 and S2) is consistent with expectations and agrees with the general tenure of the psychological theories of human development discussed in Chapter 2. (Gesell, 1940; Grantham-McGregor et al., 2007; Inhelder & Piaget, 1958). Most (93) of the children participating in the study in S2 turned 6 in the Grade R year and were in Piaget’s (1980/1952) pre-operational stage of development when young children start to think more logically (see Section 2.2 – 2.3). Therefore, the within-subjects’ effect observed in the learner-participants can also be ascribed to just normal developmental processes resulting from various biological and environmental factors that can impact on development as suggested in, for example, Piaget’s theory of cognitive development and Gesell’s maturation theory, which was discussed in Chapter2 (see Section 2.2 – 2.3). Grade R learners were also exposed by an enriching environment with educational toys, climbing frames and books, but not in the same vein as the schools in the 'well-functioning' schools, as in Stage 1.

6.2.2 H2: Exposure to Chess Instruction

Results Relating to the Second Hypothesis Between-Subjects' Effects in Groups (RH2_S2) are discussed below.

Although it was expected that a general improvement in SR scores as evidenced on the ASB would occur regarding all the Grade R learners owing to cognitive developmental processes, the specific focus of the study fell on the facilitating effect of chess playing on cognitive and scholastic aptitude skills (RH2_S2). The research findings pertaining to this (in person's) between subjects' effect, is now discussed.

At the end of the school year, there was a significant difference between the control and chess group. A pooled *t*-test, $t(114) = -7.868$, $p < 0.0001$*, at a 95 % (21.836, 26.723) confidence interval, revealed a significant difference (Diff -14.180) between the C and E groups, which was confirmed by an ANOVA of the two groups, $F(1,114) = 61.906$, $p < 0.0001$*, $\eta 2 = 0.351$, at a 95 % CL [21.836, 26.723]. The group by time effect was significant favouring the control group and not the treatment group. It was hypothesised that the chess or treatment group would display higher ASB scores than the control group after exposure to chess classes but evidently this was not the case. The null hypothesis must therefore be accepted.

The outcomes of the testing and analysis of RH2_S2 revealed that despite an improvement in SR levels within-subjects of the participants, the chess group did not fare statistically significantly better than the C group at a post level. In fact, as already pointed out, there was a significant difference between the control and experimental groups, favouring the control group. Chess instruction therefore did not have the expected effect on the SR scores in this stage of the research, as in studies of Jerrim et al. (2018) and Pells (2016).

The lack of a significant group-based effect of chess on scholastic testing scores over time in this stage could be due to various reasons (see Sections 6.4; 6.6). The theory that chess can affect cognitive development positively, is probably more applicable in younger children than in adults. Moreover, the research on chess expertise pertaining to the occurrence of transfer of learning is controversial (Gobet & Sala, 2023; Waters et al., 2002) and factors such as age, external circumstances, classroom sizes and number of learners in class, duration of chess exposure, level of training in all role-players, teachers and chess tutors, method of chess training, and actual ability in chess can all play a role in the outcome (Sections 3.7.2, 3.7.3, and 3.7.4). There is support for various theories (cognitive development theory of Inhelder and Piaget, 1958; maturation theory of Gesell, 1940; Vygotsky, 1997; sociocultural theory of Bronfenbrenner, 1979**;** deliberate practice theory of Ericsson, 1988) regarding chess expertise but in this research the children were given only basic exposure to chess playing and they were not even close to achieving proper competence and expertise in chess (see Section 2.1.2). In any case, some researchers argue that far transfer is very rare and that even if the putative benefits of chess on academic performance abilities is significant, the transfer effect will be relatively small (Gobet & Campitelli, 2006; 2007; Gobet & Sala, 2023). Thus, the lack of significant results derived from the chess instruction in Stage 2 is therefore not really relevant to the transfer issue because the children did not acquire expertise but merely exposure to chess. The learner-participants in the chess group learned more about the chess board game than the control group did, which would stand them in good stead in the following year when the learners would be exposed to chess tutoring at school.

It is more relevant to compare these results with those obtained in Stage 1 where a slightly greater increase was witnessed in the chess GIQ scores of the group than those of the control group. This effect due to chess instruction was not seen here, and one can only speculate about the reasons underlying the apparent absence of any chess influence in Stage 2. Bear in mind that some researchers (Ogneva, 2017; Scholz et al., 2008; Storey, 2000) explained that children who may experience developmental and concentration problems such as Attention, deficit, and hyperactivity disorder (ADHD), require longer periods of chess practice to memorise movements of chess pieces and special moves, with the purpose to limit stress levels and provide more automaticity and more time for important problem solving.

There were several differences between the design of the research studies in Stage 1 and Stage 2. In Stage 1, participation in the chess instruction was voluntary and the children and their parents could decide whether they wanted to take part in the chess lessons. This was not possible in Stage 2 because decisions had already been made about exposing most (if not all) schools (and learners in the Foundation Phase) in the West Rand to chess classes during school hours, and it would not have been fair to expose only some of the learners to chess instruction in the relevant schools. The chess lessons in Stage 2 were presented over a shorter period than in Stage 1, only 20 weeks instead of 40 plus weeks, and it may be that the period of chess instruction was too short to fully master the game. Thus, for it to have an effect (as proposed by Sala & Gobet, 2016; 2017; 2020), 25 to 30 hours are required for transfer to occur. It is also quite likely that systemic variables such as the schools and teachers could have played a role. Grade R teachers in the treatment group in S2 were not expert chess trainers or even experienced and well-qualified teachers because they had acquired only a one-year ECD diploma. They had little real teaching experience but had considerable teaching responsibilities and may have felt too overburdened to spend the required amount of effort on the additional task of chess tutoring during school hours. Dlamini and Maphalala (2021) reported that teachers, in a similar environment and schools in the Eastern Cape, complained of feeling overburdened in a chess project where teachers were also the chess instructors (or trainers).

There were differences between the teachers in the different developmental schools involved in Stage 2 with significant differences in terms of both qualification and experience between the teachers in the three no-fee schools, and the teachers in the former model C school in Stage 1 (see Sections 3.3, 3.4.1, 3.4.1), in a qualitative comparison. The teaching and school aspects are discussed in further detail below.

Different interventions such as chess playing are being called for by researchers, politicians, and businessmen in South Africa and worldwide to teach children new skills and to facilitate cognitive development (Gobet & Sala, 2023; Luneta & Giannakopoulos, 2016). Moreover, various researchers have reported significant improvements in math learning/performances after Foundation Phase learners were exposed to chess training in South Africa; for example, in a longitudinal study conducted by Luneta and Giannakopoulos (2016). Formative Annual National Assessments were administered by the DBE (2013) (until 11 September 2015) in Home Language and Mathematics, identifying learning needs and validating the mean scores on different measuring instruments/academic tests after chess exposure. While the Grade R learners did not form part of these groups and did not write ANAs, school readiness assessments were carried out by the teachers when feasible.

Although some researchers posit that learning to play chess may be suitable to foster problem-solving abilities in difficult subjects such as math and science, other researchers argue that there are many other educational therapies or programmes that can also enhance cognitive development (see Krog & Krǚger, 2011; Sala & Gobet, 2016). One should also not place too high expectations on chess lessons as an educational intervention because, even if the intervention is carried out properly, the influence on academic performance is likely to be small in light of the issue of far transfer to other domains (Gobet & Sala, 2023). Furthermore, Sala and Gobet (2017; 2020) believe that the working memory (WM) training (aiming at improving cognitive skills and academic achievement in typically developing children) has little or no effect on skills outside the domain of WM training such as fluid intelligence, cognitive control, literacy, and mathematics (Anderson, 1990; 1996). Furthermore, the findings of Sala and Gobet (2017) are in line with Thorndike and Woodworth's (1901) element theory, inasmuch that the occurrence of far transfer is only sporadic, and there is some support for Whitehead's educational theories (1929) which entail that different learners may require different teaching methods.

Nonetheless, chess playing does at least provide support for the important theoretical aspect of the ACT-R theory regarding declarative knowledge and procedural knowledge as well as the deliberate practice theory of Ericsson (1988; see Sections 2.1.2, 2.1.3). In chess playing and in the practical chess assessments in Stage two, good legal moves are rewarded immediately and bad or illegal moves are not allowed; in other words, immediate feedback is given followed by opportunities and suggestions to correct mistakes. Chess learning therefore follows the requirement of Ericsson's theory of deliberate practice (see De Groot et al, 1996, p. 263). However, the emphasis is placed on actual practice in this theory (and according to Whitehead, 1929, rather than on declarative knowledge), and, in Stage 2, the children learned only the basics of the game but did not really graduate to the practice component nor did they achieve the criterion of at least 25 hours (or more) of chess exposure as dictated by this theory (also see Ogneva, 2017; Sala & Gobet, 2016; 2017; Whitehead, 1929).

Inborn talent is also a factor to be reckoned with as suggested by the multifactorial gene-environment model and the general theories of intelligence discussed in Sections 2.1.4 and 2.5 (De Manzano & Ullén, 2018). It is possible that some of the more gifted children managed to learn chess playing more quickly in both stages and that a greater focus on individual rather than just group differences would have led to a more nuanced discovery of the influence of chess on the psychometric tests. Unfortunately, due to the research design and statistical analyses employed in this research, which focused exclusively on group differences, if any such more subtle effects occurred, they could not be detected owing to methodological constraints.

To summarise, when new concepts in chess playing were introduced in S1 during the demonstration chess lessons, the young learners who were not yet chess novices because they did not know the whole game, were given immediate feedback and enough time to practice while they were learning; this was not the case in the S2 group. In the deliberate practice theory of Ericsson, there is a specific need for sufficient chess practice with at least 25 to 30 hours devoted to chess learning and practice; this did not occur in S2 (see Section 2.1.2; Sala & Gobet, 2016; 2017; 2020).

Lastly, all the children in the developmental schools received daily meals but little is known about either the nutritional value of these meals in the various no-fee schools and whether the time set aside for the lunch period affected the chess instruction in any way. It was not possible to supervise such that the time required for other chess lessons was correctly and strictly observed by the teachers in all the developmental schools throughout the duration of the 20-week period.

6.2.3 H3: The Age Variable

Results relating to the third research hypothesis of Stage 2 (RH3_S2) ([in] between-subjects effect) are discussed here.

It was hypothesised that the ninety-three (+5) older children would perform significantly better on the ASB than the younger (-5 years) age group because the older children had more time to learn and develop; for example, in preparatory schools and thus they could have been in a different Piagetian stage of development (Inhelder & Piaget, 1958). In this research investigation, the age variable was not significant in the ANOVA table $F(1,114) = 3.139$,

p = 0.079 ns, at a 95 % CI [-10.295, 0.573] because the probability value was greater than the 0.5 AL. This insignificant difference (Diff = of -4.861) was confirmed by the Pooled and Welch *t*-tests, indicating equal variances. Consequently, there was not a significant difference between the two age groups (see Section 4.6; Appendix D [1 – D6]).

The output of the two-way ANOVA analysis with repetition further revealed that both age groups contributed mainly to the (main) time factor of improvement in the SR levels over time.

However, there was not a significant interaction between time and age $F(1,114)$ =3.139, p = 0.079 ns at a 95 % CL [-10.295, 0.573] and there was not a significant difference or an in-between factor or reversed order, in favour of the older children or age group, between age groups $F(1,114)$ = 2.924, p = 0.090 ns at a 95 CI [-10.295, 0.53]. The older learners did not display higher levels of SR than the younger learners and the H0 must therefore be accepted with regard to this hypothesis of Stage 2.

These research outcomes in RH3_2 are slightly inconsistent with various developmental theories (of Piaget, 1980/1952; Erikson, 1972) which posit that there are developmental stages and therefore that age differences are reflected in cognition and scholastic performance. The findings in this study, though, support the occurrence of the maturation/development theory, implying that all children will go through all the stages but at their own rate (Gesell, 1940). However, in this research, most of the children in the different groups were very close in age because they were all in the pre-school phase and they were all in the same general stage of cognitive development. It should also be borne in mind that individual intellectual abilities are also important. Hence, as mentioned there were a few individual children in these groups (in S2) who were more advanced in their cognitive and scholastic abilities than the others, as detected by the Aptitude Tests of School beginners, but the focus in S2 fell on group testing and group differences when some were exposed to chess classes and others not. In any case, there were no significant age-related differences in the ASB scores of the children at this stage. The study conducted by Chitiyo et al. (2023) did not confirm the findings in this hypothesis because differences between grade levels, age and gender were revealed in their study. For example, the purpose of their study was to determine differences in perceived benefits of chess for learners by gender and age after being exposed to chess for a year. The results showed that elementary learners consistently tended to have higher ratings of perceived benefits than middle and high school learners across all constructs. The differences between middle and high school learners were low and not statistically significant.

6.2.4 H4: Gender Variable

Results Relating to the Fourth Research Hypothesis RH4_S2 (Between-Subjects' Effects of the Two Genders)

It was hypothesised that there will be a significant (in-between) difference between the performance of boys and girls in classes when they are young and still developing, and boys will obtain higher scores on the mean Global ASB test at the second time point owing to various anthropological and social theories stage (see Adani & Cepanec, 2019; Ananthaswamy & Douglas, 2018).

To further explore the relationship between chess instruction and SR as represented by mean scores on the ASB, the differences between the male and female gender groups were investigated by employing different tests and analyses. In hypothesis RH1_S2, it was found that the participants in both groups improved significantly over time, $F(1,114) = 61.906$, $p < 0.0001$*, at a 95 %/CI, [-17.751, -10.610] which obviously included both the boys and girls. The Pooled t-test and ANOVA revealed no significance with regard to the gender variable (for a difference of Diff = -1.437); Pooled $t(114) = -0.643$, $p = 0.521$ ns, at the 95 % CL [-17.751, -10.610] (see Appendix D [1 – D6]).

A two-way multivariate analysis of variance (MANOVA) with repetition revealed that both the two gender categories (boys and girls) improved significantly over time, $F(1,114) = 261.509$, $p < 0.0001$*, at 95 % CL [-5.864, 2.989], but there was no interaction between the time and gender variables, $F(1,114) = 0.414$, $p = 0.521$ ns, at a 95 % CL [13.803, 21.609]. However, there was a significant difference for the (in) between (gender) subjects' effect at a post level, $F(1,114) = 10.3372$, $p < 0.0017$* at a 95 % CL [15.881, 21.694], indicating that the girls performed significantly better than the boys on the ASB test at the end of the time interval. The boys did not display higher SR scores as predicted at the second timepoint, the girls performed better, and therefore the null hypothesis must be accepted.

Although there was not an effect of gender attributable to the chess intervention, it is noteworthy that the girls did improve significantly more than the boys in their ASB scores, suggesting that there was a gender effect in some aspects of their cognitive development. According to Wallentin (2009) girls' language skills appear to be slightly better than boys' language skills in young children but this difference disappears very quickly as the children mature and grow. It is possible that in this case the boys lagged slightly behind the girls in their cognitive improvement in these early years of development and maturation as measured with the SR scores (see Sections 3.1 and 3.2). Not much can be interpreted from these apparent gender differences in scholastic development because there could be cultural, socio-economic, or even school-based factors at play. However, there is some research suggesting that young girls are capable to process verbal information more quickly than young boys would; this could have had an effect on the psychometric testing at this stage (Adani & Cepanec, 2019). However, it should be noted that there was no significant gender-based effects in Stage 1, so other factors also played a role in Stage 2.

6.2.5 H5: School Groups and Teacher Groups Variables

Results relating to the (in) between-subjects' effect of the schools and teachers (RH5_S2) are discussed in this section.

6.2.5.1 Schools. The ANOVA analysis revealed significant differences amongst the adult teachers (as evidenced in the mean scores of the learners on the ASB) involved in the three schools as hypothesised, where $F(2,113)$, = 34.685, $p < 0.0001$* $\eta 2 = 0.38$ with a small to medium contribution of the time factor at a 95 % CL [21.836, 26.723]. There was also a different order of performance in the schools from the pre to post level. However, contrary to expectations, the two schools in the treatment group did not fare significantly better than the Sepedi school in the C group. Therefore, the *H0* must be accepted because the two schools in the chess group did not perform better than the schools in the control group at the post level.

6.2.5.2 Teachers. In the current research investigation, it was hypothesised that there would be significant differences between the teacher groups (as reflected by the mean School readiness scores [of ASB] of the learner-participants). However, at the pre level, there was not a significant difference between the teacher groups, $F(4,11)$, = 01.848, $p = 0.124$ ns, at a 95 % CL [2.349, 29.777] but there was a different order of performance between the teachers and classes (as evidenced in the learner-participants' mean scores on the ASB), from a pre to post level. The teachers in the Setswana class performed better than the other groups at a pre level but the Sepedi classes seemed to perform better than the Setswana and English teachers at the second time level as suggested by the two-way ANOVA (MANOVA) output. However, the important point is that the two classes in the treatment group did not improve significantly more than the classes in the control group as one would expect from the research hypotheses concerning the effect of chess on scholastic performance. As a result, the null hypothesis for RH5 (between-subjects) has to be accepted as there was no significant difference between chess instruction and school readiness scores of the Grade R learners at this stage (see Sections 3.6.2, and 3.7.4; also see Sala & Gobet, 2016; 2017; Jerrim et al., 2018; Pells, 2016).

All the teachers and learners improved significantly during the (school) year as evidenced in the school-readiness scores of the ASB test. A significant difference for the *within-subjects' effect of the teachers' performance* (over time) was revealed in MANOVA, when the *p*-value was smaller than the 0.05 alpha level, $F(1,111) = 431.946$, $p < 0.0001$*, at a 95 % CI [2.349, 29.777]. The interaction between the teacher and time factors was also significant, $F(4,111) = 18.325$, $p < 0.000$*, at a 95 % CI.

Afterwards the schools and teachers involved in Stage 2 were analysed and compared in a qualitative manner (see Sections 3.4., 3.4.1.; 3.4.2; and 3.4.3.). This comparison indicated that some of the Grade R class teachers in the developmental schools in S2 did not have the proper Grade R qualifications, lacked real experience, and were not sufficiently familiar with the CAPS curriculum. The teachers in the chess group were also not really qualified and competent chess players or trainers. They functioned in an environment with insufficient resources and support and found it difficult to cope with all the demands of preparing learners for formal school. These factors could have exerted an impact on the execution of the chess lessons and the general school experience of the children in the chess treatment groups, as supported by Dlamini (2018) and Dlamini and Maphalala (2021) (see Section 6.4).

6.3 Value of the Study in the Community

When researchers conduct research, it is beneficial for the various stakeholders or role-players, especially for the learners who were young children. The reason being that the study could include the development and improvement of the body of knowledge and information that drives innovation (Hatmi, 2023), as in the current two studies (stages 1 and 2). It also enables humans, namely young children, to live healthier and more prosperous lives in an educated manner. In fact, scientific research is also necessary to disprove inadequate or inaccurate research claims, for example, that chess classes always enhance cognitive abilities in typically developing children, when it ties together observations, knowledge, and data to solve present or future problems, to develop solutions and generate new ideas (Gobet & Sala, 2017).

Thus, this applied science also allows individuals, industries, and countries to put information to the test in transforming abstract theory such as the theory of deliberate practice or transfer of learning into practical applications, which is one of the factors that confirms the importance of scientific research (Ericsson, 1988). Thus, the main goal of investigating young Grade R learners in different educational environments after exposure to chess instruction, first in a former model C school (in S1) and then in developmental schools (in S2), was to investigate if and how cognitive, general aptitude skills, and intellectual skills can be significantly enhanced in different environments and to establish the way forward. Additionally, such research provides more information to the various ongoing debates in the chess domain (see Section 6.3.2).

Moreover, further qualitative questioning and investigation revealed that the children in the experimental group in S2 initially knew nothing about the chess game when the lessons began (DuCette, 2009).

However, after being exposed to mostly demonstration games and some instruction once into the game, they did acquire at least some chess knowledge. The teachers in the developmental schools also learnt more about the chess game as well as ways to incorporate chess within the CAPS Grade R curriculum, how to manage large groups, and how to divide lessons and activities according to a written Grade R Chess Curriculum that was provided to them at the onset of this research investigation. Thus, the research conducted in this study may pave the way for a more systematic implementation of chess as an activity in these schools.

The research also yielded insight into various conditions for the satisfactory application of a chess playing intervention in Grade R schools such that the effect of the general educational environment in the school, the importance of devoting sufficient time to chess playing (i.e., the minimum required 25 hours of chess instruction), and the reality of the problematic far transfer of chess training to other domains of cognition and academic performance (see Section 3.6.2; see also Gobet & Campitelli, 2006). Lastly, some screening and reporting of possible abnormalities amongst the children by the chess facilitator and the chess trainer is important when the children were engaged in the practical chess assessments, so that proper psychological and educational interventions can be applied. The teachers are able to attend to and report to the relevant therapists, issues such as faulty pencil grips, lack of fine motor or gross motor skills (or stiffness), poor tracking skills on the chess board, faulty basic mathematical skills, and speech, eye, or hearing problems. Hence, the additional benefit of an early detection of required therapeutic interventions in children who perform weakly is a consequent side effect of chess lessons.

6.3.1 Contribution to the General Research Regarding the Role of Chess in Education

Very few studies have explored the cognitive effects of chess playing in very young children such as Grade R learners and research results are often inconsistent (see also Frydman & Lynn, 1992; Parsons, 2014; Sigirtmac, 2012; Sallon, 2013). Furthermore, there is very little reliable data relating to the assessment of the cognitive (scholastic) abilities of chess players in general (Gobet & Campitelli, 2006; Waters et al., 2002). Therefore, the two studies in stage one and two contributed to psychological knowledge by exploring the relationship between chess playing and school readiness as well as intellectual, and cognitive development in a scientific manner in different environments.

The research also paved the way for future investigations because the results suggested that chess intervention can sometimes affect scholastic development poorly (as in S2) but that this is not always the case. Further research is therefore needed about the role of systemic variables such as school environments, teaching conditions, the duration of the chess classes, the content and method of teaching chess, and the chess knowledge and competence of the facilitator and trainers (Sala & Gobet, 2016).

6.3.2 The Nature-Nurture Debate in Intelligence

Both studies (S1 and S2) may have some relevance in broader debates in psychology regarding the role of nature and nurture in cognitive development and school preparedness. All the learners in the two groups exhibited a slight improvement (a significant *within-subjects' factor*) on the JSAIS and the ASB psychometric test at the post level assessments. Participants in both stages exhibited an average increase in the mean scores of the two measuring instruments during the time interval as predicted by theories of cognitive (Piaget, 1980/1952) and biological development (Hambrick et al., 2019; Spratling, & Johnson, 2006) and maturation (Gesell, 1940; see Sections 2.2, 2.1, and 2.1.1). However, there is no clear evidence favouring either side of the nature-nurture debate, because the specific contribution of the nature and nurture components cannot be determined from the methodology of this study.

There could have been nature effects because some children were quicker to understand what was expected from them compared with some of the other children. The apparently more gifted children also tried to complete the scholastic tasks as quickly as possible and did so without requiring further explanation. In a study carried out by Robinson, et al., (1996), they postulated that certain developmental changes occur early in mathematically precocious young children and that these high mathematic skills can be picked up early in young children. The math scores of such children remained high for two years after enhancing their mathematical development.

However, this nurture aspect in this thesis is based on mere speculation when observing them during the chess lessons and has no real scientific basis. They were just Grade R learners in developmental schools, mostly doing work in the official Grade R CAPS workbooks; examples of their worksheets to examine these for individual differences could not be obtained. In poverty-stricken areas, the growth and development of some children are stunted due to malnutrition and nutritional deficiencies such as protein or iron, with subsequent architectural changes in the brains of the small children (Mlachila & Moletsi, 2019; Van Dyk & White, 2019). While this phenomenon leans more towards a nurturing effect or an interplay between the nature and nurture effects, this could also not be investigated in this study (also see Britto, 2012; Landsberg et al., 2005; see Section 3.6).

6.3.3 The Expert-Novice Theory and Issue of Transfer Revisited

Although the chess effect size in the Stage 1 study was small, the results provide some support for the postulated effect of extended practice (of twenty hours) on the enhancement of cognitive abilities in a particular domain (Ericsson, 1988). However, the pattern of the results obtained does not really support or refute the theoretical explanations of the expert-novice shift and transfer possibilities to other domains underlying chess playing (Anderson, 1990; 1996; De Groot, 1946; 1978; De Groot et al., 1996; Ericsson & Lehman, 1996; also see Sections 1.4.2; 1.2.2; 2.1; and 3.7). When young children are initially exposed to chess classes, their knowledge bases are small and their memorising skills are poor but as they learn and practise the new skills, their knowledge bases gradually increase in both magnitude and quality as they gradually become more skilled (Malamed, 2009; Robinson & Persky, 2017). However, this takes time, continued practice, and guidance (see Section 2.1.1).

Although there was not a significant chess effect demonstrated in the ASB scores of the chess playing children, they all learnt to position and manipulate certain chess pieces on a chessboard and they had developed some understanding of the game at the second time point. They certainly knew more about chess than they did prior to the chess tutoring. If one supposes that these learners were to continue with chess instruction in the next year after the intervention, they would be able to build upon what they had already learnt in Grade R. Thus, even if chess instruction did not have any observable effect on scholastic skills in the testing period, continued chess teaching and practice may well exert an effect on scholastic performance over time (see Luneta & Giannakopoulus, 2016). However, this is obviously just speculation and cannot be verified in the current research because a longitudinal design and a different research methodology would be required.

6.3.4 Male Dominance or a Patriarchal System Worldwide and in South Africa

The controversy about gender differences in some domains is an ongoing debate both worldwide and in South Africa. While it is possible that gender differences can account for the high incidence of men in the fields of engineering and computer science, this male dominance is gradually diminishing and more females are also beginning to enter and excel in these domains, also see Ananthaswamy and Douglas (2018), and Adani and Cepanec (2019). In this current research, this type of male dominance was not observed in the second stage because the girls slightly outperformed the boys in the second ASB testing.

Debates about gender-based differences favouring young boys in some areas of cognition such as mathematics are ongoing and further research is therefore needed to determine whether the pattern of results among the young children in Stage 2 constitutes just an isolated case resulting from the school system and perhaps cultural factors, or whether similar results can be replicated in future research studies (Robinson et al., 1996).

6.4 Limitations and Recommendations

The research in both the first and second stages was conducted with only young children, Grade R learners, and different results may have emerged if older children were the participants, as was the case in certain other studies (Waters et al., 2002). The aim of pointing out limitations or characteristics of the design or methodology that influenced the interpretation of the findings of this research study, in this discussions chapter, is to demonstrate critical thinking about the topic so as to understand literature addressing this relevant topic, and to consider the chosen methodology most appropriate in the research.

Thus, there were limitations of the generalisability or utility of findings in both stages, mostly over which the researcher had no control. For example, the following limitations were encountered.

6.4.1 General Factors due to the Quasi-Experimental Design

It is possible that the parents of the experimental group in S1 engaged in chess playing with their children at home, which could have contributed to slightly higher increases in the GIQ and PIQ scores. However, in the same vein, it is possible that the children in the control group could also have learned how to play chess during playmate visits. Hence, the amount of chess playing after school hours was not controlled in the S1 study. Furthermore, these children could have engaged in more extra-curricular activities than the participants in the control group, possibly because their parents were more affluent. One could assume that other activities could also have fostered the slightly improved development of performance intelligence in the chess group such as movement programme of Krog and Krȕger (2011). Moreover, the more gifted children in this group who mastered the game more quickly than classmates could have contributed the most to the slight cognitive gain reflected in the post-test PIQ scores of the experimental group. Lastly, it is also possible that the specific method of chess instruction used by the chess instructor, who was also the psychometrist in Stage 1, could have facilitated the learning process. Hence, it is possible that there could have been a transfer of motivation, from the trainer to the learner-participants.

It should be borne in mind that an improvement in the PIQ scale will also lead to higher scores on the GIQ, as in Stage 1. Therefore, the effect of chess classes on cognition was evident only in the performance or fluid intelligence of the children. This effect was sufficient to produce a slight increase in the general intelligence of the chess group compared with that of the control group.

In Stage 2, it is probably unlikely that young children who live in poverty-stricken areas, with limited access to resources and who were exposed to chess classes, would have been exposed to chess practice at home with their parents. These geographical areas lack resources, especially as chess sets can be expensive (Kiki & Kotze, 2019).

Recommendations were made in the discussions of S1 and S2 for future studies.

6.4.2 Possible Sampling Bias and Threats to Validity

Randomisation as a method of sampling is required in experimental studies because it enables the researchers to better control nuisance and extraneous variables and to ensure that any statistically significance observed between groups in an experimental study can be unequivocally attributed to a possible effect of the intervention. However, randomisation in this study in both S1 and S2 was not feasible for ethical reasons. Learner-participants could not be randomly allocated to the two groups because, in S1, the parents subscribed their off-spring to voluntary chess playing and, in S2, the young children in developmental schools in the West Rand all received chess classes during the testing period.

In S1, many parents were thrilled to hear that their children could be exposed to chess playing during school hours, and they evidently believed that chess playing would enhance their future intellectual development and educational abilities of their children (Christiaen & Verhofstad-Denève, 1981). Consequently, in S1, the parents of the chess group indicated their preference to devote attention and resources to allow their children to participate in the chess lessons. This was not the case in S2. In this stage, not all the schools were allowed the opportunity for their children to participate in chess lessons. Only certain schools were chosen to be exposed to chess instruction. In both stages there were therefore factors that hampered randomisation. In Stage 1, the parents had to consent to the classes while in Stage 2, stakeholders in the surrounding areas sponsored the chess classes. Parents or legal guardians in both groups gave voluntary consent on behalf of their children to form part of this research investigation.

There are only limited or no extra mural activities available for young Grade R learners in no-fee schools. The chess classes were presented during school hours, due to various reasons, but mostly due to the fact that children make use of public transport, and the drivers pick them up at specific times (Bruwer, 2014; 2018).

Lastly, it is possible that the specific method of chess instruction used by the chess facilitators and teachers could have contributed to (mostly in S1) or slowed down (mostly in S2) the learning process in S2. The teachers may not have been aware of facilitating the process when presenting the new material, that is the rules of chess playing, in a meaningful manner by relating it to pre-existing knowledge to facilitate the understanding and insight. Some parents do not live with their children at home/nearby and thus they could not discuss daily activities with their children, thereby not further facilitating the learning process, as well. Also, the children were not given ample opportunity to practise, as proposed by Jeanne Ellis Ormrod (2006, pp. 271-273; also see McDevitt & Ormrod, 2013; Whitehead, 1929; Storey, 2000).

Thus, in both S1 and S2, it was not possible to control all the extraneous variables. Such control is required for true and rigorous experimental designs due to the potential bias derived from a sampling process based on voluntary participation in chess classes. The external validity of the research can therefore not be guaranteed yet there is at least some reason to assume that the results of S1 may also hold true for other White, Afrikaans speaking Grade R learners in primary schools in South Africa**.** S2 is more problematic because more extraneous variables could not be controlled; there was the potential bias stemming from a convenience sampling of the school. Therefore, the external validity of this research cannot be assumed to be valid and generalisable to other Black and Coloured, Setswana, Sepedi, and English speaking (multilingual) learners in developmental primary schools in South Africa.

6.4.3 Lack of Pair-Wise Comparisons of Intelligence

It is recommended by researchers that, when intelligence tests are included in studies, pairwise comparisons by matching two participants from each group on each intellectual level should be performed. While such comparisons were omitted in the studies of both the stages, they could have been included in Stage 1 after the JSAIS psychological tests were used at a pre level to assess intelligence (Basson, 2015).

The ASB test of S2 is a school readiness test and not an intelligence measure, and it was not possible to assess intelligence individually due to limited time, funds, and the various home languages. However, robust statistical analyses were employed, and in future, such a test can be included in similar studies. When two participants are being matched on one intellectual level, better control of the intelligence factor will occur. This could have made a more significant contribution to the ongoing nature-nurture debate in the chess domain, thereby yielding a sounder method for determining the effect of the treatment variable.

6.4.4 The Use of Sound Research Designs, Methods, and Instrumentation Issues

The Global ASB test is available in nine of the twelve official languages in South Africa, according to Mindmuzik Media (2000; see Section 4.1.1). Therefore, it is possible that young children experience language barriers when they attend schools not in their own home language and for example the English/Afrikaans teacher (with fifty Grade R learners in class), was not able to translate the instructions into the desired African language (Section 3.6). However, most of the tests of the ASB can be understood in a non-verbal manner, and the rationale of most of the tests and practice examples were demonstrated on a green or white board. Still, the ASB group test is a psychometric instrument that has been adapted for young Grade R or Grade 1 learners in South Africa in nine languages.

The two measuring instruments used in the two stages in this current investigation are both still widely in use in South Africa. Many experienced psychologists in clinical practice make use of two intelligence tests, for example, the JSAIS and Cattell's culture free scale, and they compare the results of two or more psychometric tests with one another (Theron, 2013; Van der Merwe et al., 2022). Unfortunately, this strategy could not be followed in this research due to practical difficulties and the constraints imposed by testing groups of very young children.

6.4.5 Possible Methodological Limitations

Even though the sample in Stage 1 (S1) was small it met the requirements, and the sample in the second stage (S2) was larger but should have been preferably even larger. One class in the experimental group was exposed to very little teaching and learning owing to teacher absenteeism. Consequently, if the ASB would have been used, the assessments would have been invalid, and therefore this class could not be included in the sample. Moreover, as already explained, randomisation in the selection and assignment was not possible in both the stages, and convenience samples had to be used owing to both ethical and practical constraints.

In the former Model C school, parents subscribed and paid for their children to receive chess lessons while in S2 young children were sponsored by small businesses in the surrounding area. All these plans were already in place prior to the onset of this current research investigation.

Furthermore, there were no active control groups in both the stages. The control school or group in the second stage was located in a different area in Gauteng because all the schools in the West Rand area had already received chess classes. The research took place in one province in South Africa. Therefore, the results or findings can be generalised to only Gauteng even though different schools were included in both the stages.

6.4.6 Measure or Psychological Assessment Test Used to Collect the Data

It is possible that there could have been validity issues affecting the instruments because the widely used JSAIS and ASB are both old measuring instruments with outdated norms and, furthermore, bias was mentioned in the ASB Manual. However, researchers have not regarded this as problematic. A pilot study was conducted by Parsons (2014), when she assessed young preschool learners on the ASB, prior to chess exposure and after the chess tutoring, in a poverty-stricken area to gain more knowledge.

All the learners-participants in S1 and S2 were also observed and their behaviour was recorded both during the assessments, the measuring instruments, and or during the practical chess assessments so as to obtain a more accurate picture (see also Theron, 2013). Moreover, qualitative information was also gathered in the second stage of the research investigation and the teachers in the different schools or educational settings were compared with one another. As mentioned before, the two measuring instruments, the JSAIS and ASB, and norms, can be adapted/modified to suit the requirements of test users, such as researchers, psychologists, psychometrists, and experienced psychometric tests developers, to increase the validity of these tests and produce valid (raw) data.

With relevance to self-reported data, all the role-players (principals, teachers, and the chess facilitator) in S2 were asked to fill in a questionnaire to obtain strict demographical and more educational information in an explanatory study. Questionnaires were additionally sent out to the parents or legal caretakers (in S1 and S2), but a poor return followed when only a few parents filled it in; therefore, no information was used (see Appendices A, B & C). All the other information about the demographical factors was already known in Stage 1, a homogenous environment.

6.4.7 Test Conditions

In both stages 1 and 2 of the research investigation, the test conditions at the pre and post levels were similar and the guidelines in the Manuals of the JSAIS and ASB tests were closely followed. Though, note that in individual assessments as in S1, a young child can focus better when alone, than when there is a small amount of normal external disturbance, as during a group test (ASB), in S2 (McDevitt & Ormrod, 2013). Unfortunately, individual testing was not possible in S2 due to the limited time period. Nonetheless, the learners-participants became more test-wise in S1 and S2 at the second testing and obviously had gained some prior knowledge as they had become more familiar with the procedure that had to be followed.

The post assessments in Stage 2 had to take place before the end of November because, in developmental schools, the children do not attend school after the completion of the Grade R CAPS curriculum, as reported by Parsons (2014) after a study undertaken in Tembisa. In fact, despite the researcher trying to take this into account, some of the learners in the English class had already left school for financial and transport reasons, in S2.

6.4.8 Fluency in a Language

This research study in S2 included young children in different schools involving different teaching languages. Therefore, the teachers and assistants read out the instructions in the ASB psychological tests when the school readiness test was administered to the Grade R learners because the researcher could speak only English and Afrikaans. In class, the teachers and chess facilitator who were multilingual (all except for the English teacher), translated the instructions to the learners where possible.

This multilingual environment was a challenge for the teachers in class due to the variety of official home languages in South Africa (see Section 3.5; Erling et al., 2017; Albertyn & Guzula, 2020). However, when assessing learners on the ASB, the test relies mostly on non-verbal testing but the instructions were read out of the manual and graphical illustrations were used (as required in the manual) to clarify to the learners what was required of them. These illustrations were drawn on the blackboard and ample practice examples were provided during the ASB assessments. The teachers also identified and assisted some of the learners with language barriers in each class (see Section 3.6.2).

6.4.9 Lack of Prior Research Studies on the Topic and Lack of Available and/orReliable Data

Very little prior research on the topic of the effects of chess playing on cognitive and aptitude skills in young six-year-old children exist, in particular pertaining to Grade R learners in South Africa and worldwide and especially in cases where they are exposed to various amounts of chess playing. In both the studies (S1 and S2) of Basson, the young children were not asked to fill in surveys or to provide answers to questions about their enjoyment of various activities, including chess. According to some researchers, young learners who had been questioned about chess playing and other educational activities, mentioned that they preferred outdoor games, computer games, chess, lego, or other activities on a computer in the respective order as mentioned (Güneş & Tugrul, 2017).

A lack of data or reliable data would likely require a limitation of the scope of the analysis and the size of the sample or it could become a significant obstacle in finding a trend and a meaningful relationship. Some researchers have found support for studies that investigated cognitive and academic effects after exposure to chess classes but the outcomes of the research studies with young children differed from those involving adults; there were inconsistencies in the results (Frank & D'Hont, 1979; Frydman & Lynn, 1992). However, Parsons (2014) investigated the effect of chess tutoring on cognitive and scholastic skills in Grade R learners (over a short period) in a very small sample and reported a positive outcome, even after two years. This researcher was also the psychometrist and chess instructor in the stated pilot study. Although the latter sample was very small, the results were similar to those obtained in the S1 study.

6.4.10 Possible Limitations of the Researcher (i.e., Late Access to Schools)

In S1, the researcher was granted permission to inform parents about the intended study in the Grade R arena and to commence with assessments as soon as the new school year commenced. In S2, the principals in some schools provided more information to the parents about the intended research project and all the relevant parties had to give consent to this project.

In developmental schools, prospective researchers are required to visit the schools to discuss further arrangements but access to the developmental schools, the GDE granted the researcher access for only a short period. Thus, there were time issues in making arrangements regarding the assessment dates and only a limited period was granted for exposing the children to the treatment variable. Consequently, in S2, less than the desired amount of chess practice was available, which, according to theory, was less than the (approximately 25 to 30 hours) of time required to transfer new information and learning from chess to other cognitive domains (also see Sala & Gobet 2016; 2017).

6.4.11 Longitudinal Effects

In both studies, it was unknown what the longitudinal effects of learning chess would be. In S1, the Grade R learners were exposed to twenty hours of chess classes, and the theoretical lessons were immediately followed by chess practice. As stated, in a pilot study conducted by Parsons (2014), longitudinal effects were still present after a few years; it is therefore possible that there could have been some longitudinal effects but this was not followed up in S1. It is still possible to conduct future follow-up studies for the S2 study. At present, it appears that some learning had occurred based on the chess lessons in S2, because learner-participants were introduced to the chess game, and they acquired some knowledge, which they did not have before. Future research studies can address this issue about the possible longitudinal effect of chess instruction since not much is currently known about this phenomenon.

6.5 Conclusions

6.5.1 General Conclusion of Stage 1

The objective of the study, which was conducted in two stages, was to investigate the relation between chess instruction and the development of cognition and intelligence by using two samples of young children. One sample was drawn from a standard Quintile 5 public school in Pretoria and the other sample, from three developmental Section 21 schools in poverty-stricken areas in Gauteng.

In Stage 1 (see Section 4.1.1), the results revealed statistically significant differences between group means of the Performance and General intelligence scales at a 95% confidence level [PIQ] $F(1,62) = 4.15$, $p = 0.046$* and [GIQ] $F(1,62 = 6.25)$, $p=0.015$*, 95% CL, which indicates a relation (combined effect or interaction) between chess instruction over time and intelligence. The magnitude of the relation (partial eta square = 0.063) was small, with the time factor, not the chess factor, contributing more to this relation. The control and experimental groups increased over time in terms of the within-subjects' effect for PIQ, VIQ (Verbal intelligence scale), GIQ and Numerical scales [PIQ] $F(1,62) = 55.46$, $p < 0.000$*; [VIQ] $F(1,62) = 60.65$, $p < 0.000$*; [GIQ] $F(1,62) = 94.064$, $p < 0.000$*; [NUM scale] $F(1,62) = 14.90$, $p = 0.000$* at a 95 % CL. The time factor contributed 47 % towards the variance in PIQ; 49% variance to VIQ, a large contribution of 61 % to GIQ, and a very small contribution of 19 % variance to the NUM scale.

In the second stage, the focus remains on teaching chess to young Grade R children but this time the research was carried out with three no-fee schools instead of the Quintile 5 standard school reported in Section 4.2. At this stage of the research, the objective was to explore the effect of learning to play chess on the development of young children's cognitive scholastic performance in historically disadvantaged areas. The participants were sampled from various schools and constituted two groups, namely a group receiving chess instruction and a group that was not exposed to chess playing. These groups were then compared utilising a multilingual group test, the Aptitude Tests for School Beginners, at two different time points to establish whether chess playing had any effect on the school readiness scores of the Grade R learner-participants over time.The two groups that were studied consisted of a Sepedi (control) school in Mamelodi, and two (Setswana and English) schools in the Randfontein area, which constituted the experimental group. In the second stage, the treatment group formed part ofa social upliftment programme.

6.5.2 General Conclusion of Stage 2

All the teachers and learners in the groups or schools in the two age groups and the two gender groups (see Section 4.1.2) improved significantly during the time interval [Groups] $F(1,114) = 61.906$, $p < 0.0001$*, at a 95 % CL [15.981, 20.354] as evidenced in the SR scores of the Aptitude Tests for school beginners in RH1_S2 (in Stage 2).

The outcomes of RH2 revealed that despite of an improvement in the SR levels of the participants, the chess group did not statistically fare better than the control group who were not exposed to chess tutoring at a post level $F(1,114) = 0.194$, $p < 0.660$ ns, at a 95 % CL [7.496, 126.703]. While statistical analysis indicated that there was a significant difference between the control and treatment groups, this favoured the control group.

The outcomes of RH3_S2 revealed no significant differences between the two age groups in Stage 2, and no interaction.

In RH4, the boys did not display higher SR scores at the second time point as hypothesised but the girls displayed higher school readiness scores at a post level. The significant difference was: $F(1,114) = 10.3372$, $p < 0.0017$* 95% CL [15.965, 21.609] and the *H0* was accepted, in RH4_S2.

In RH5_S2, there were significant differences amongst the learner-participants in the relevant classes and the teachers in this current investigation. There was a different order of performance between the different teachers and the classes at a post level. While the teachers in the Sepedi classes performed better than the Setswana and English teachers, this was not (statistically) confirmed by the two-way ANOVA output. Moreover, at the post level, there was not a statistically significant difference between the teacher groups, $F(1,114) = 3145.951$, $p = 0.124$ ns, at a 95 % CL [2.349, 29.777]. The two classes in the E group did not improve significantly more than the classes in the C group, the reverse actually occurred. Hence, the null hypothesis for RH5_S2 (between-subjects) was accepted as there was no significant difference between chess playing and school readiness scores of the Grade R learners.

6.6 Final Implications and Recommendations

The limitations in both quasi-experimental studies have been discussed, and some recommendations for future research are suggested.

The focus in this research study in both the stages mainly fell on instructing children on how to play chess during two respective periods (20 and 40 weeks). Additionally, in S2, the learners in the chess group were assessed on their practical chess playing skills after the eighteenth week of chess exposure in a practical learning assessment. Some of the moves of the chess pieces (the white and black kings, queens, rooks, and pawns) were practised by two players at a time. It was not possible to only assess one child alone due to time restrictions because there were as many as fifty learners in one experimental class. After being exposed to ten hours of chess instruction, the learners knew much more of the chess game than before with enough to build upon if they were to be given further chess classes in future.

One weakness of the S2 study is that the C group resided in a different area in Gauteng than the E group but this could not be avoided due to ethical and practical constraints. The schools and the Grade R classes in the West Rand area were all sponsored for chess classes by small businesses in the area as part of a social upliftment project. Take note that one school in the control group of a study by Luneta and Giannakopoulus (2016), resided in Uganda. The preliminary results in Luneta and Giannakopoulus (2016) revealed a correlation between chess playing and the learning of math, in South Africa.

Further information concerning the relative abilities of the learners, in particular their worksheets, in class could not be obtained in S2 because the learners mostly worked in their annual Grade R CAPS workbooks, and these were not made available to the researcher. Future researchers should try to obtain more information about the academic abilities, for example, the Annual National Assessments (of the DBE, 2013) for participants, in use until 2015, so that this aspect can be taken into account in the analysis.

Furthermore, because this was a quasi-experimental, exploratory, rather than a true experimental study, there are a few aspects that can affect the validity; hence, the generalisability of the results was limited to only one province. These methodological limitations should be addressed in future studies.

6.6.1 Questions or Debates that Remain Unanswered

The research which took place in two stages involving different educational environments, has addressed an important part of a rather complex issue but several important questions remain unanswered. Thus, the following issues emerging from this research have not yet been satisfactorily addressed:

- How permanent will the cognitive gains be for all learners, after being exposed to enriched educational environments, and chess classes in different groups in both stages?
- Will the chess confer a more noticeable effect over time on the cognitive development and academic performance of the chess group? In other words, will there be some (far) transfer of learning chess over a longer period than just the 20 weeks?
- Will age and gender variables become more important in chess performance and the possible cognitive transfer of chess playing to other domains as these young children mature?
- If the teachers-participants in developmental schools as in S2 gain the necessary qualifications and educational experience, and they receive intense chess training, will there be significant increases in the cognitive and academic abilities of the learners after being exposed to chess training?
- Chess instructors or trainers (or expert chess players) are not all good teachers when instructing chess to young learners but, if experienced instructors were employed in a follow up study, will the chess group reap significant cognitive results?
- Since both nature and nurture variables seem to be important in chess expertise, how can the role of nature and nurture factors be determined in research studies?

- Are all the meals provided at no-fee schools in South Africa, of the same quality?
- More specifically, are there any other socio-economic environmental variables that could have played a role in chess playing that were not considered in this research study?
- What would the results be if the control group were to be exposed to a different boardgame, for example, Go or checkers, or if the chess group were given blended lessons?

From a philosophy of science point of view, science is a problem-solving activity (like chess playing) that constantly generates new problems to solve, which in turn requires further research to the extent that this study has raised several issues that still need clarification and therefore it has succeeded in this endeavour (see Laudan, 1978). Thus, even if there are still many unsolved issues, this research has at least provided some further insight into puzzling relations between chess ability, cognition, and intelligence.

6.6.2 Final Remarks

The research questions regarding the existence of a relationship between chess and intelligence as represented by the PIQ, VIQ, Num scale and GIQ of the JSAIS in Stage 1 and chess and cognitive skills as represented by the ASB in stage 2 were addressed. In the first stage of the research (S1), two weak relationships were identified between chess classes over time and intellectual development such as the PIQ and GIQ where a *group * time* interaction was found which can be ascribed to the chess treatment factor. In the more exploratory and practical stage of the research (S2), no significance relationship was obtained between chess playing and cognitive skills. This lack of significance could be due to various systemic variables, as discussed in this chapter.

The 'two-stages' study attempted to make some contribution to the topic of chess, intelligence, and cognition. However, there are still many issues that need further exploration, especially in relation to the many nuisance variables that could have played a role. Furthermore, by investigating or exploring chess playing in two different educational environments in Gauteng, it emphasised differences between public schools in a First to Third world country, when young children were exposed to chess playing. In a Quintile 5, standard public school (S1), the school and learners can be regarded as 'ready to engage in chess playing' but various external factors seemed to have exerted an impact on the no-fee schools. The schools and the learners were also much less ready to play chess than their counterparts in S1 at the same Grade R level. Nonetheless, the association between aspects of intelligence and chess, and cognition and chess revealed in this study, is certainly of considerable scientific value, particularly in the light of the growing interest in many countries, including South Africa, to make use of chess as a means to offer additional intellectual or cognitive stimulation.

6.7 Recommendations and Further Research

This research investigation has revealed many caveats and possibilities for continued future research on the topic of chess as an educational instrument for young children (see Section 1.12). Some of the aspects that need to be taken into account regarding the insignificant (in) *between-chess effect* in Stage 2 are:

- The importance of gathering more information about previous research studies and relevant findings, as in meta-analyses. Furthermore, researchers believe that colleagues should continue to search the web for meta-analyses or employ it in future research where numerous studies are discussed and ample information is provided, which could guide further studies. New researchers could combine this with their own new research.
- In future, methodological changes can be made (see Section 3.7.3). For example,

a) larger sample sizes can be used to combat the drop out of participants in longitudinal studies; b) random selection and assignment must be used as in the study carried out by Luneta and Giannakopoulos (2016); c) two control groups can be added and one group can be the active control group (by playing Go or checkers; although young children do not yet have ratings that can be compared or grouped in a study); and d) both/all groups (control and experimental) must be situated in a certain area.

After testing or assessing intellectual abilities, pairwise comparisons (in matched pairs) can be made with two learner-participants on the same level of IQ, to control for nuisance variables. However, this could be very labour intensive and expensive owing to the many relevant or applicable official languages (see also Erling et al., 2017; Van der Merwe et al., 2022).

Moreover, test distributors/experienced psychologists in South Africa should update and/or adapt the outdated tests and norms of the old psychometric tests (ASB and JSAIS) so that more valid research results can be achieved.

- Researchers must be aware of the important factors or role-players in a chess domain prior to exposing young learners to chess instruction. For example, the chess capabilities (and experience) of chess trainers, facilitators or instructors; the type or level of training that they received; the method of instructing and content of learning material or chess curriculum (a standardised chess curriculum is preferred by fellow researchers), plus experience of working with young children (see Gobet & Sala, 2023). Young children, as well as children with developmental problems must be given enough time for practice, for example, more than once a week (see also Sala & Gobet, 2016; Storey, 2000; Ogneva, 2017). Teachers who are involved with chess training and are not experienced chess players, must receive good, specialised chess training but only after the Grade R teachers have completed their ECD teaching degrees or diplomas. Moreover, it would enhance research in the chess domain if the chess curricula are standardised or if the relevant topics and study matter are disclosed in future studies.

- According to Haijian et al., (2011), blended or mixed lessons (for example, combining chess lessons with mathematics or fun activities for the children) could also be an option, although Gobet and Sala (2017) have warned fellow-researchers not to replace traditional math with chess classes. Moreover, all the participants can be blinded (not being aware of the relevant information in a research study), because the participants must purposely not be informed of the reasons of the research or the possible chess effects that are being investigated pertaining to chess classes.
- Follow-up research studies or longitudinal research studies should also be employed, with the latter conducted over a fairly long period after the learners have been exposed to chess playing (Luneta & Giannakopoulos, 2016).
- The focus of investigation or that which the researcher wants to investigate and transfer in near transfer must be more specific and more closely linked to school performance and the scales of the psychometric instruments (for example geometry and chess playing) (see Section 3.6.2). More information and research should be carried out regarding the various diets used by different feeding schemes in developmental schools in the different districts, but different schools and their environments also need to be further researched (also see IOL, 2021). If the DBE manages to incorporate Grade RR into schools in future, the even younger children will be exposed to structured educational curricula and routines and, in poverty-stricken areas, additional meals and the stated exposure could improve their physical health (Bronfenbrenner, 1979).
- Lastly, worksheets, test results or school reports of learner-participants should be obtained to provide greater insight into the individual school performance of the

participants so that this aspect can be explored in combination with the psychometric testing to improve the external validity of the research (Van der Merwe, et al., 2022).

The findings in these two studies have contributed to theory and ongoing debates regarding the relationship between chess and cognitive development and some guidance for future research has been suggested. The study also added new relevant research regarding the application of chess (to Grade R learners) as an educational instrument in a developmental context, an aspect which has not yet been systematically investigated by researchers in this country but where there are many nuisance and systemic variables that play a role, as revealed in this research. The study served to again emphasise that chess is a complicated game and that promoting chess playing in young pre-school children may promote academic and intellectual abilities but that the link between chess and cognition is far from simple and many factors could play a role in the successful transfer of the visuospatial intelligence gained from chess playing to other cognitive domains.

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Appendix A

Learner Consent to Participation in this Study

(available in English)

Informed Consent for Participation in the Research Study for a Learner

The parents and guardians were informed about the purpose of the study, and what it entails prior to the onset of the research investigation.

The participants' rights are:

The purpose of the study is for research purposes and the results will only be used as such, therefore no feedback will be provided to parents.

Participation is voluntary and participants have the right to withdraw at any time without penalty.

Participants' results of assessments would be treated confidentially and only the researcher will have access to the results.

Although the names of the participants were known to the researcher and entered into statistical programs, anonymity of the names of the participants would be adhered to for their protection, when discussing the results obtained in this study.

Lastly, both children and parents were thanked for their contributions.

Hereby I declare that I have read the above information and have a clear understanding thereof. I have had sufficient opportunity to ask questions and I agree with all statements made.

Hereby I (name and surname), ____

Parent or legal guardian of_________________ ______ **(child's name and surname**) consent to participation of my child in the research study as part of the experimental group (YES/NO) or the control group (YES/NO)

I am aware of the fact that this research study entails psychometric assessments at different periods, and that I will be notified when and where it will take place.

CHILD's DATE OF BIRTH: ____

NAME OF LEARNER's CLASSROOM: ____

SIGNATURE OF PARENT OR GUARDIAN:__________________________DATE:________

RESEARCHER's NAME AND SURNAME ____

RESEARCHER's SIGNATURE ____

Appendix B

Adult-Participants: Consent to Participate in this Study

Hereby I____________________(participant's name) confirm that I am aware of the purpose of the study, the procedure, potential benefits and probable inconvenience of participation.

The study was explained to me and I understood the study as explained to me.

I have had sufficient opportunity to ask questions and I am prepared to participate in this research study.

I understand that my participation is voluntary and that I am free to withdraw at any time without any consequences.

I am aware that the findings of this study will be processed into a scientific document or into a research report, but I am aware that my participation will be kept confidential.

I have received a signed copy of the informed consent agreement.

______________________________ ____________________________________

PARTICIPANT NAME & SURNAME PARTICIPANT SIGNATURE

____

DATE

______________________________ ____________________________________

RESEARCHER's NAME RESEARCHERS'S SIGNATURE

____

DATE

Appendix C

Questionnaire for Role-Players

(School Principals, Teachers and Chess Facilitator)

Name___________________________________

Date of Birth______________________________

Culture Group_____________________________

Language of Learning______________________

School_________________________________

Work experience (number of years)___________

Number of years Teaching experience_________

Do you have to attend in-service teaching training from the DBE______________________

Are you a student__________________________

Three-year Diploma or Degree_______________

Do you write exams during the year___________

Do you follow the CAPS curriculum____________

Are you involved in transport arrangements for the learners after school____________________

Would you describe your physical classroom as large enough or too small ___________________

Is the bathroom next to/near your classroom ____

Where do the children eat (inside the class or outside on the playground)__________________

____

Do you have your own assistant in your class, or do all the Grade R class teachers share one assistant_________________________________

Surname__________________________________

Age______________________________________

Home Language____________________________

What languages do you speak________________

Name of Class (where applicable)_____________

Types of work_______________________________

Teaching Qualifications________________________

Other Qualifications (where applicable)___________________________________

What are you studying________________________

Institution you are studying through____________
____

If so, when__________________________________

Do you find the curriculum easy or difficult
____

If so, what is expected from you____
____

How many learners do you have in the class_____

Is the playground next to/near your classroom___

Does your school have a variegated vegetable garden to supplement the National Feeding Scheme___________________________________

Were you involved in the chess initiative at school where you had to give chess classes to learners_________________________________

What are your dreams for the children in your class____________________________________

DATE OF COMPLETION OF THIS FORM

____

NAME___________________________________

____

SIGNATURE________________________________

____

NAME OF RESEARCHER________________________

RESEARCHER's SIGNATURE_

____

Do you have to attend in-service training pertaining to chess tutoring__________________

Appendix D

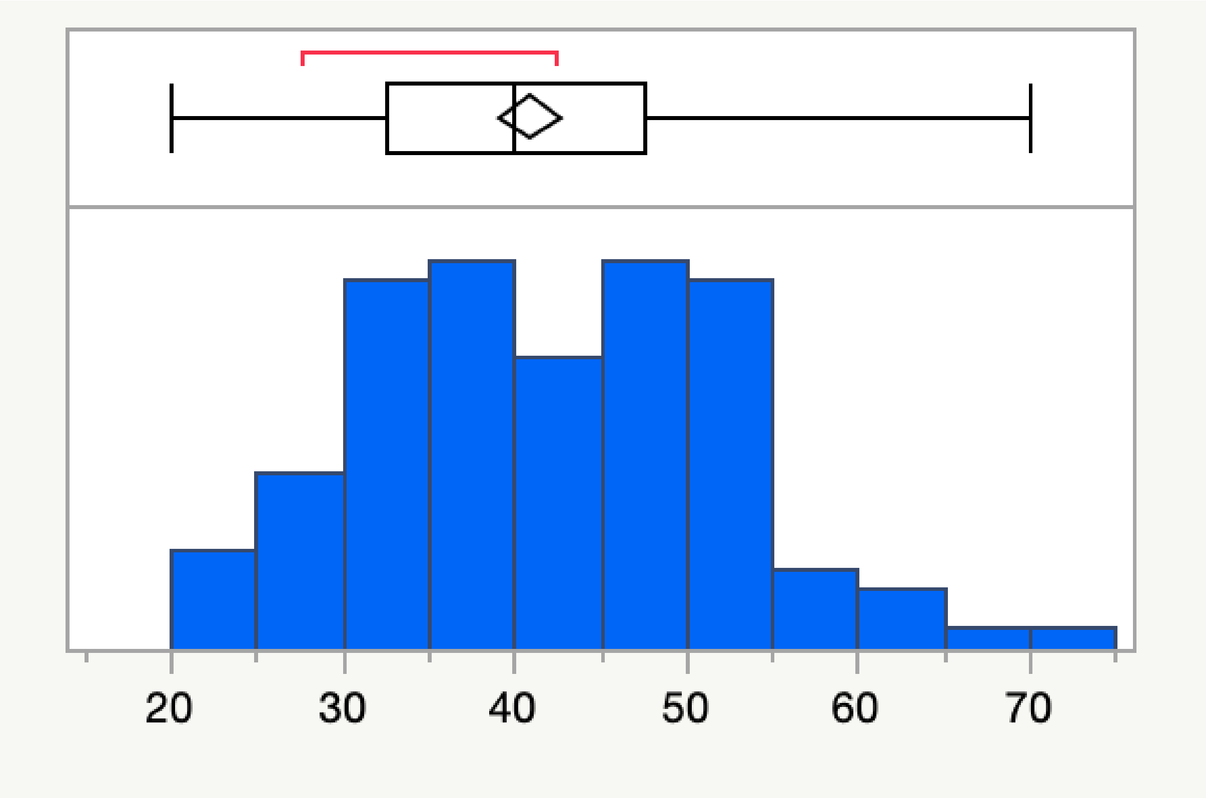
DESCRIPTIVE STATISTICS OF STAGES ONE AND TWO

D1 Descriptive statistics: Assumption of Normality (histograms)

The histograms and boxplots (whisker plots) display the distributions of the ASB scores of the two groups (C and E) at the pre-test and post-test, as well as the Total Difference at the Postlevel. (Also see a display of interval data on continuous data).

Figure D.1:

Total PRE



Quantiles

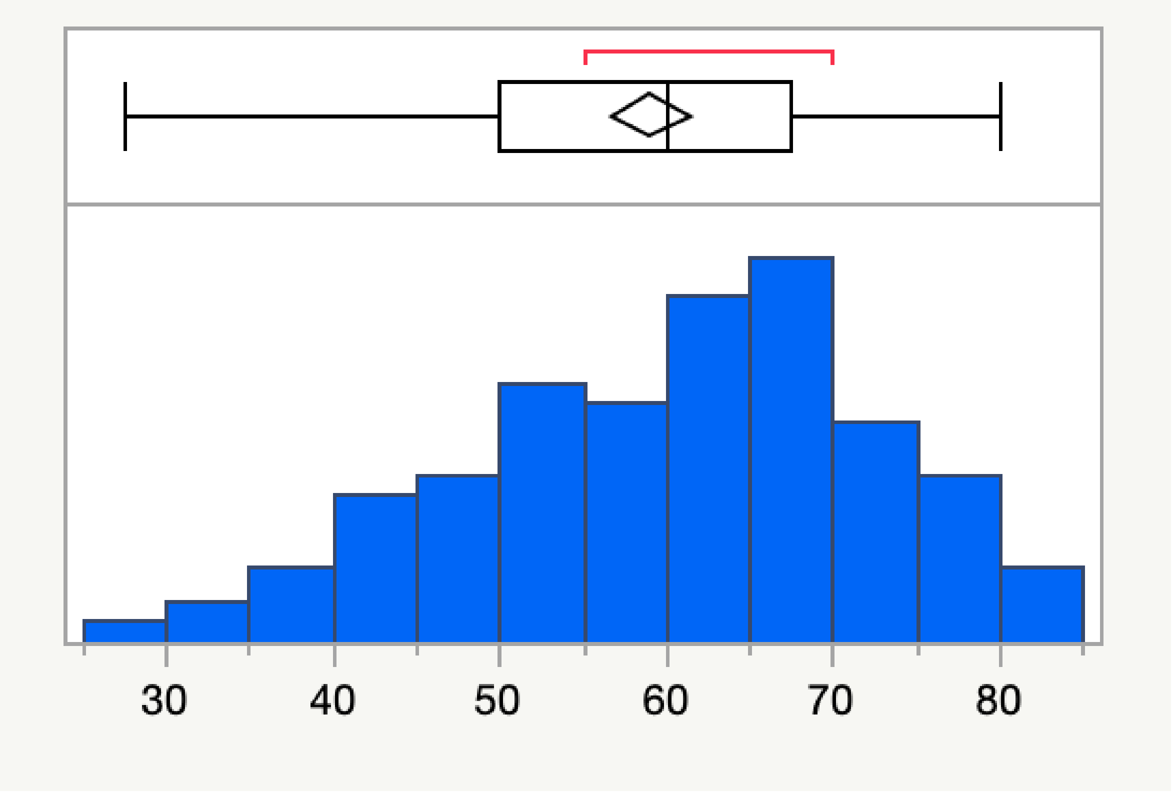
100.0%	Maximum	70
99.5%		70
97.5%		62.88
90.0%		52.5
75.0%	Quartile	47.5
50.0%	Median	40
25.0%		32.5
10.0%		27.5
2.5%		22.5
0.5%		20
0.0%	Minimum	20

Summary Statistics

Mean	40.862069
Std Dev	10.263398
Std Err Mean	0.9529325
Upper 95% Mean	42.749645
Lower 95% Mean	38.974493
N	116
Skewness	0.2683176
Kurtosis	-0.259964

Figure D.1:

Total POST



Quantiles

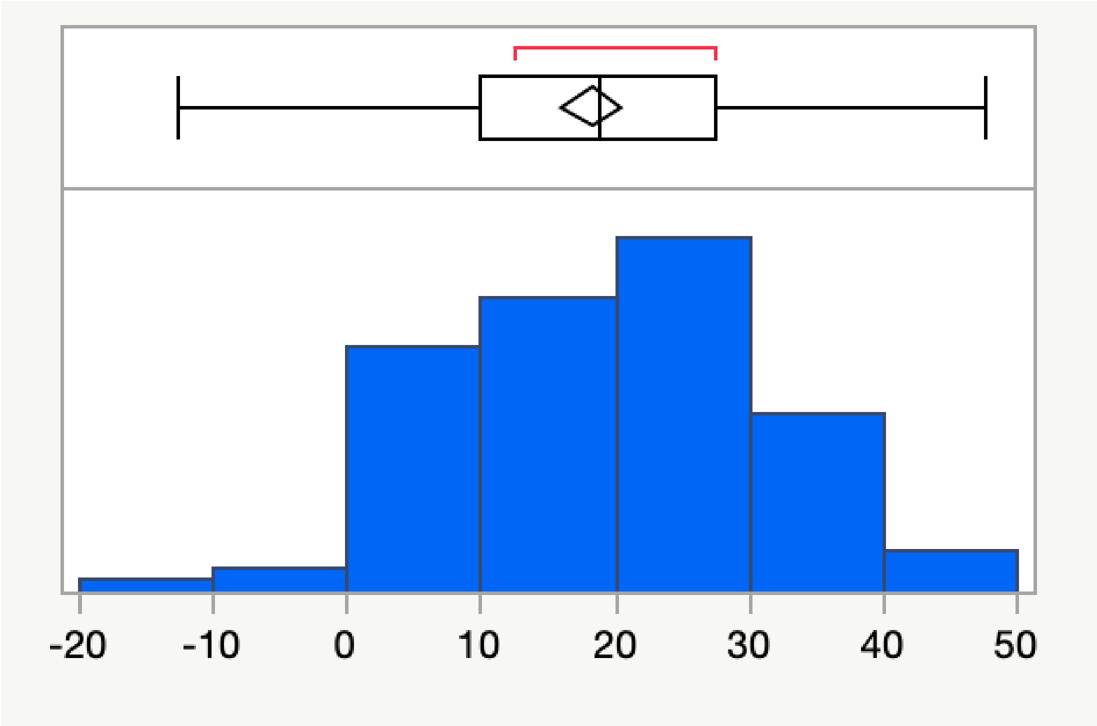
100.0%	maximum	80
99.5%		80
97.5%		80
90.0%		75
75.0%	quartile	67.5
50.0%	median	60
25.0%	quartile	50
10.0%		40
2.5%		32.3
0.5%		27.5
0.0%	minimum	27.5

Summary Statistics

Mean	59.030172
Std Dev	12.255307
Std Err Mean	1.1378767
Upper 95% Mean	61.284087
Lower 95% Mean	56.776258
N	116
Skewness	-0.388176
Kurtosis	-0.473984

Figure D.1:

Diff total



Quantiles

100.0%	maximum	47.5
99.5%		47.5
97.5%		45
90.0%		32.5
75.0%	quartile	27.5
50.0%	median	18.75
25.0%	quartile	10
10.0%		2.5
2.5%		-2.6875
0.5%		-12.5
0.0%	minimum	-12.5

Summary Statistics

Mean	*18.168103*
Std Dev	*11.888786*
Std Err Mean	1.1038461
Upper 95% Mean	20.35461
Lower 95% Mean	15.981597
N	116
Skewness	0.0470385
Kurtosis	-0.370639

D2 Assumption of homogeneity

Table D.2:

EqualityTests (that the Variances are Equal)

Level	Tests	F-Ratio	DF Num	DF Den	*P*-value
Group_2 Diff	O'Brien [.5]	0.413	1	114	0.521
	Brown-Forsythe	0.003	1	114	0.951
	Levene	0.021	1	114	0.883
	Bartlett	0.365	1	.	0.545
	F Test 2-sided	1.177	65	49	0.553
Months 2/Age Diff	O'Brien [.5]	0.486	1	114	0.486
	Brown-Forsythe	1.794	1	114	0.183
	Levene	1.439	1	114	0.232
	Bartlett	0.385	1	.	0.534
	F Test 2-sided	1.239	92	22	0.580
Gender (M/F) Diff	O'Brien [.5]	0.501	1	114	0.480
	Brown-Forsythe	0.241	1	114	0.624
	Levene	0.417	1	114	0.519
	Bartlett	0.388	1	.	0.533
	F Test 2-sided	1.181	49	65	0.524
School Diff	O'Brien [.5]	0.464	2	113	0.629
	Brown-Forsythe	0.765	2	113	0.467
	Levene	0.803	2	113	0.450
	Bartlett	0.464	2	.	0.628
Teacher Diff	O'Brien [.5]	0.963	4	111	0.430
	Brown-Forsythe	0.827	4	111	0.510
	Levene	0.920	4	111	0.454
	Bartlett	0.883	4	.	0.473

alpha level 0.01

Note: Tests the *H0* that the error variance of the DV/outcome variable is equal across groups a.

Design: Intercept + Group/School/Teacher

Within-Subjects Design: Time

Note: Tests indicate equal variances at a 99% CL, except for O'Brien's test, which indicates equal variance at a 0.5 AL (*n*=116)

D3: Assumptions of Equality of Covariance across groups.

Table D.3:

Box's Test of Equality of Covariance Matrices[a]

Group	Box's M	F test	df1	df2	Sig.
C and E	1.775	0.581	3	6625916.479	.628
C and E (schools)	7.695	1.242	6	45638.890	.281
C and E (Teachers)	14.178	1.135	12	69205.744	.326

Note: Tests the *H0* that the observed covariance matrices of the DV/outcome variables are equal across groups/schools/teachers. ª Design: Intercept + Group/School/teacher; Within Subjects' Design: Time

D4: Assumptions of Sphericity

Table D.4:

Mauchly's test of Sphericity a

					Epsilon b	Epsilon b	Epsilon
Within Subjects Effect	Mauchly's W	Approx. Chi-Square	Df	Sig	Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Time	1.000	.000	0	.	1.000	1.000	1.000

SPSS (2020): Tests the *H0* that the error covariance matrix of the ortho-normalised transformed SRscores (DV) is proportional to an identity matrix.

a. Design: Intercept + Group/School/Teacher and Within-Subjects' Design: Time
b. It may be used to adjust the degrees of freedom for the averaged tests of significance.

D5: Summary of *t*-tests as Used in Stage Two: Pooled *t* tests, Welch Tests and

2-Sample Tests

Table D.5a:

Pooled t tests

Source	Df	*t*- ratio	*P*-value
Matched pairs/one sample (Diff between Total Post and Pre level/Diff total)	115	16.458	< 0.0001*
Diff total by Groups (C + E)	114	-7.868	< 0.0001*
Diff total by Months 2 (Age -5 and +5)	114	-1.771	0.079ns
Diff total by Gender (M/F)2	114	-0.643	0.521
Diff total by School	116	-	-
Diff total by Teacher	116	-	-

CI 95%

Table D.5b:

Welch t tests

Source	DF Num	DF Den	F-ratio	*t*-Test	p-value
Matched pairs (Diff total)	-	-	-	-	-
Diff total: Groups (C + E)	1	109.64	63.325	7.957	<.0001*
Diff total: Months 2 (Age)	1	36.731	3.577	1.891	0.066ns
Diff total: Gender (M/F)2	1	100.75	0.404	0.636	0.526ns
Diff total: School	2	49.005	36.219	-	<.0001*
Diff total: Teacher	4	53.144	20.361	-	<.0001*

CI 95%

Table D.5c:

Two Sample t-test

Source	DF	S	Z	Prob>IZI
Matched pairs (Diff total) -	-	-	-	
Diff total by Groups (C + E)	116	1764.5	-6.475	<.0001
Diff total by Months 2 (Age -5 and +5)	116	1564.5	1.564.5	0.129
Diff total by Gender (M/F)2	116	2813	-0.622	0.533
Diff total by School	-	-	-	-
Diff total by Teacher	-	-	-	-

CI 95%

D6 Summary of ANOVAs

Table D.6:

One-way ANOVAs

	Source	DF	Sum of Squares	Mean Square	F Ratio	Prob>F
	Group_2	1	5720.408	5720.41	61.906	<.0001*
Diff	Error	114	10534.064	92.40		
	C. Total	115	16254.472			
	Months 2/Age	1	435.702	435.702	3.1399	0.079ns
Diff	Error	114	15818.770	138.761		
	C. Total	115	16254.472			
	GENDER (M/F)2	1	58.817	58.817	0.414	0.521ns
Diff	Error	114	16195.655	142.067		
	C. Total	115	16254.472			
	School	2	6182.928	3091.46	34.685	<.0001*
Diff	Error	113	10071.544	89.13		
	C. Total	115	16254.472			
	Teacher	4	6464.770	1616.19	18.325	<.0001*
Diff	Error	111	9789.702	88.20		
	C. Total	115	16254.472			

DV = SR, alpha 0.05