Stef Esterhuizen & Mary Grosser

Improving some cognitive functions, specifically executive functions in grade R learners

Abstract

This study established the effects of a researcher-developed curriculum-based intervention programme. The intervention was grounded on principles of Feuerstein's ideas about 'mediated learning'. The aim of the intervention was specifically to address children's executive functions, which are generally regarded as prerequisites for cognitive development. We studies a selected group of South African grade R learners (n = 20). A quasi-experimental design was employed to collect quantitative data on rotational basis from experimental groups A and B, by means of dynamic assessment with the Children's Inferential Thinking Modifiability (CITM) test during pretest, post-test and delayed post-test occasions. The test data was intended to elicit the extent to which the intervention that had focused on enhancing executive functions had contributed to the participants' application of cognitive and metacognitive skills and strategies. Qualitative data captured participants' application of cognitive processes in the input, elaboration, and output phases of the designed learning process, as well as the characteristics of their inhibitory control functions. A striking finding was the improvement noted in the children's application of the following executive functions, namely working memory, cognitive flexibility and inhibitory control.

Keywords: Cognitive development, executive functions, dynamic assessment, grade R learners, mediated learning, cognitive modifiability, Feuerstein

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Introduction

Many South African learners repeat grade 1, and only 46% of grade 1 learners reach grade 12 (Rademeyer 2008). According to the Wes-Kaap Onderwysdepartement (2006), retention in grade 1 could be attributed to inadequate school readiness programmes and learning problems related to poor cognitive development.

The effectiveness or not of additional pre-school interventions to improve cognitive development in grade R is no longer a debate: Pre-school intervention improves individual achievement and problem-solving skills (Anderson, Shinn, Fullilove, Scrimshaw, Fielding, Normand & Carande-Kulis, 2003; Rossbach, Kluczniok & Isenmann, 2008; Rossbach, Kluczniok & Kruger, 2008). Authors also agree that early intervention enables the young learner to monitor, detect and self-correct errors, and has the potential to improve the young learner's capabilities and detect early developmental delays (Jeon 2004).

According to Barnett (2008) pre-school intervention and education not only prove to be of great social and economic value for a country, but also promote a child's lifelong learning. Burger (2010) argues that early childhood intervention programmes have positive short-term, as well as long-term effects on cognitive development, especially with children from disadvantaged socio-economic backgrounds. Moreover, according to Karoly, Kilburn and Cannon (2005:1), early childhood education and intervention programmes promote holistic development, which include physical, emotional, social and cognitive development. In a longitudinal study, Reynolds, Temple, Ou, Robertson, Mersky, Topitzes and Niles (2007:730) found that individuals who were exposed to an early childhood intervention programme, showed higher rates of school completion and educational attainment. Young learners who participate in an early social and cognitive development programme transit to school more easily than those who are not exposed to such a programme (McFarlane, 2006; Smith, 2009; Swanson, 2006).

Although the cited studies provide evidence that early childhood education and intervention programmes can have a lasting impact on cognitive development, none of the studies have documented the effectiveness of infusing a *mediated learning* approach across the curriculum for enhancing cognitive development among grade R learners (preschool learners or kindergartners).

With Reuven Feuerstein (Feuerstein, Feuerstein & Falik 2010:25), we argue that cognitive development of grade R learners can be improved if mediated learning experiences are central to daily teaching and in the learning experiences that this creates. On this view *mediated learning* proposes that learners receive and process information in a systematic, exploratory and reflective way, develop a need for precision and accuracy, demonstrate spontaneous comparative and inferential thinking behaviour and acquire higher order thinking skills (Feuerstein & Feuerstein 1991:11). Although this appears to be a 'basketful' of premises of this approach, many years of research has shown that Feuerstein's ideas have promoted an integrated,

mediated approach to teaching children (and others) (Tzuriel, 2001:72; Benjamin, 2009; Tzuriel & Shamir, 2010:49).

We set out with this inquiry, wanting to have tentative hypotheses to guide the execution of the study:

> H_o = A mediated learning approach will have no statistically significant effect on the cognitive development of grade R learners.
>
> H_a^1 = A mediated learning approach will have a statistically significant effect on the cognitive development of grade R learners.

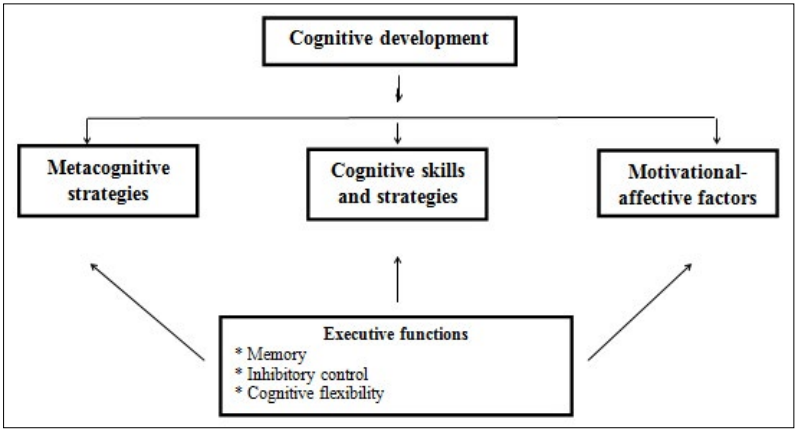
Cognitive development in grade R

The strongest evidence for the importance of wholesome early childhood development, including cognitive development, comes from neuroscience. Brain cells grow rapidly during the early childhood development period (0–9 years), making this age period apposite to address problems related to cognitive development and to create healthy development conditions for all children (Lerner, 2006; Lerner & Johns, 2009; Rademeyer, 2007). Children in the grade R age group require well-developed cognitive and metacognitive skills and strategies to perceive, think, solve problems, understand and remember effectively, and purposeful attempts should be made to develop these skills (Bolani, Pissarra, Hendricks, Swanepoel & Opie-Jacobs, 2007:v). Goswami and Bryant (2010) support the importance of cognitive development at a very early age. In contrast to Piaget's developmental stages of thinking, they argue that some structures for thinking are in place from a very early age, for example, an approximate number system and an object filing system for numbers (Henning and Ragpot, under review). Moreover, they endorse Vygotskian principles of development and learning, such as social learning (in the sense that all signs and symbols are semiotically mediated from a social and cultural source), collaborative activity that should take place in an authentic settings where a child's out-of-school experience should relate to the child's school experience and where the teacher can bring understanding about by means of thoughtful guidance (Goswami & Bryant 2010). Wright (2013:3) says that it is necessary to enhance the abstract reasoning of grade R learners, to which Brewer (2007:4–5) and Van Staden (2005:51) add the importance of active and interactive involvement in activities where teachers use sensory learning to enhance learners' cognitive development.

The multidimensional nature of cognitive development is explained widely in the literature. Cognitive development is defined as change in mental, thinking and reasoning ability patterns involved in learning, attention, memory, language, thinking, reasoning and creativity (De Witt 2009:55–56). Changes in mental ability patterns require the development and use of cognitive and metacognitive skills and strategies, some of which relate to self-efficacy (Brewer, 2007; Wegerif, 2006), as well as motivational-affective factors (Tzuriel 2001:72) or "non-intellective" factors (Feuerstein & Feuerstein 1991:6). The control and execution of these aforementioned cognitive and metacognitive processes and motivational-affective factors are coordinated and

managed by a system of executive functions (Lezak, Howieson & Loring 2004:35), or according to Feuerstein, "cognitive functions" (Feuerstein, Feuerstein & Falik 2010:71–82). The acquisition of a combination of cognitive and metacognitive skills and strategies, as well as strategies to deal with motivational-affective factors, stands central to the authors' conceptualization of cognitive development, which is clarified in figure 1 below.

Figure 1: Conceptualisation of cognitive development



Cognitive skills can be of lower order (skills for recalling information) and higher order (skills to classify, categorise, synthesise, analyse, and think critically and creatively and to evaluate information) (Brewer, 2007; Fisher, 2005; Sangwan & Chhikara, 2003; Wegerif, 2006). Cognitive strategies comprise complex actions, which require the execution of a number of steps, like problem-solving, decision-making and conceptualising (Brewer, 2007; Epstein, 2008; Lerner, 2006; Moseley, Baumfield, Elliott, Gregson, Higgins, Miller & Newton, 2005; Sangwan & Chhikara, 2003). Metacognition involves an individual's awareness of and control over his or her cognitive processes when facing cognitive challenges. Metacognitive strategies help learners to become self-regulated learners who can plan, control and evaluate their knowledge and thinking (Fisher, 2005; Flavell, Miller & Miller, 2002). In this regard, Fitzpatrick (2012:8) emphasizes the importance of cognitive self-regulation processes to sustain commitment, engagement and persistence during learning, remaining focused on tasks and being flexible to adapt to different task demands. It would seem that an important part of being a grade R learner is to become self-effective – to learn to manage learning and participation for school life. To be an executive of oneself.

According to Lezak et al (2004:35) executive functions contribute to the effectiveness and functionality of cognitive and metacognitive processes. These functions are highly interactive and describe the way in which learners perceive sensory information, transform the information, store, retrieve and use the information in order to cope successfully with cognitive challenges (Esterhuizen

2012:14). Executive functions are therefore critical and intrinsically related to effective cognitive development and change. With this in mind our research is centred on improving the three dimensions of executive functions, namely, working memory, inhibitory control and cognitive flexibility (Best & Miller, 2010; Diamond, 2006; Miyake, 2009; Miyake, Friedman, Emerson, Witzki, Howerter & Wager, 2000), with the purpose of establishing how children's improvement in the three dimensions may contribute to their overall cognitive development (execution of cognitive and metacognitive processes and motivational-affective development).

Another aspect of cognitive development that needs mention is working memory. With age, the capacity of children's working memory gradually increases to enable them to retain and manipulate information that is required for complex thinking (Luna, Garver, Urban, Lazar & Sweeney 2004). Working memory plays an important role in being successful with task completion and problem-solving (Blair & Diamond 2008) because different sets of information are attended to and integrated or discarded and some information is inhibited. Inhibitory control involves the development of good thinking dispositions such as the capacity to master and filter thoughts, resisting temptations and distractions, avoiding impulsive working ways and being able to pay selective and focused attention (Diamond, 2006; Ritchhart & Perkins, 2008). Inhibitory control furthermore involves the application of strategies to 'manage' motivational-affective factors (Tzuriel 2001:72), or in Feuersteinian discourse, non-intellective factors, such as a need for mastery, frustration tolerance, fear of failure, confidence and vitality and alertness, that play an important role in cognitive development (Feuerstein & Feuerstein, 1991:6).

Frustration and disappointment might be experienced due to prior learning failures that often manifest as low self-concept and a lack of self-confidence. In addition, learners often withdraw from instructional communication and lack the willingness and persistence to complete a task successfully. Fitzpatrick (2012:11) argues that underdeveloped executive functions in young children may lead to limited engagement in the classroom. Also, a lack of inhibitory control strategies can manifest in working behaviour that is often characterised by sporadic responses, guessing behaviour and blaming others for mistakes (Benjamin, 2009; Feuerstein et al, 2002:140–141; Tzuriel, 2001:50–55, 72–73). The third dimension of executive functions, cognitive flexibility, refers to the ability to adapt to different task demands and applying different cognitive and metacognitive skills and strategies (Diamond 2006).

The executive functions or "cognitive functions" (in Feuersteinian discourse) play important roles in the input, the elaboration and the output phases of the learning process (Feuerstein et al 2010). Feuerstein et al (2010:71–73, 74–75, 76–81) argue that impaired executive functions affecting the input phase manifest as deficiencies regarding the quantity and quality of data collected by an individual when confronted with a specific problem. In addition, learners will demonstrate vague perception, unplanned and impulsive behaviour, possess poor verbal tools to discriminate between objects and establishing relationships between events, and difficulties with labelling objects. Moreover, learners will have trouble with spatial orientation,

temporal concepts and conservation of constancies (Feuerstein et al 2010:71–73). Problems in the elaboration phase manifest in an inability to perceive, define and solve a problem, and deficient verbal potential will restrain learners from expressing their thoughts (Feuerstein et al 2010:76–81). Impediments in the output phase involve inadequate communication of final solutions to problems, trial and error responses and impulsive behaviour (Feuerstein et al 2010:74–75). The results of information processed in the elaboration phase are not conveyed clearly and precisely, facts are not thought through before reporting them, and information is not conveyed with confidence (Feuerstein 2007).

Tzuriel (2001) argues that the best way to assess cognitive development is through a teach-test-teach approach referred to as *dynamic assessment*. Dynamic assessment theory posits that learners should be engaged in active and flexible instruction, during which teachers observe how well the learner can learn under favourable conditions. Dynamic assessment utilises a scaffolded approach which, according to the authors, provides a better measure of intellectual potential that a static test; dynamic assessment enables the altering of cognitive functioning while observing changes in learning and problem-solving (Lerner, 2006:72; Snow & Van Heme, 2008:425). We applied dynamic assessment principles to measure the extent to which a mediated learning approach altered the grade R learners' cognitive functioning, specifically their executive functioning abilities.

Mediated Learning Experience (MLE)

Mediated learning is, in Feuersteinian discourse, a teaching approach that focuses on intentional intervention to specifically enhance the executive functions that are critical to the effective application of cognitive and metacognitive skills and strategies such as memory and cognitive flexibility (Feuerstein & Feuerstein, 1991:3; Feuerstein et al, 2010:25; Tzuriel & Shamir, 2010:49).

The theory on mediation is rooted in the perspectives of Vygotsky, Nyborg and the Neo-Piagetians (Cèbe, 2002; Nyborg, 1993; Vygotsky, 1986). These authors agree on the importance of *mediation* in cognitive development, the importance of task-intrinsic motivation and shared activity during learning (Haywood 2003). The authors' perspectives differ with regard to the role of the teacher during mediation, as the work of Vygostky illustrates – the central tenet being *semiotic mediation* (Vygotsky 1978:52), in other words, meaning of signs, symbols and tools are mediators that the teacher uses as person mediator. The teacher can play a low-key role in guiding learners to 'discover' information and solve problems on their own (neo-Piagetian) (Cèbe, 2002; Paour, 1992), or a dominant role (Nyborg and Feuerstein) (Feuerstein & Feuerstein, 1991; Nyborg, 1993; Vygotsky, 1986). The Vygotskyian concept of mediation involves two kinds of mediation. Firstly, a human mediator is required to apprentice a child with cognitive tools for enhancing thinking processes. Central to equipping learners with cognitive tools is social interaction and communication that aid the acquisition of verbal tools and self-regulation that are important determinants of development

(Vygotsky 1986). Nyborg (1993:) refers to mediation as teaching that fosters intelligent inquiry, and teaching that provides optimum conditions that will contribute to learners acquiring the prerequisite skills, strategies and dispositions for future learning, and enable the transfer of acquired skills, strategies and dispositions.

In contrast to the theories of mediated learning, neo-Piagetian mediation theorists argue that teachers/mediators construct their interactions with learners in the classroom to help learners to reduce their dependence on an external mediator, thus promoting self-mediation (Cèbe, 2002; Paour, 1992). The mediator in neo-Piagetian terms plays a directing role, rather than an instructing role, and therefore favours questioning to stating. For neo-Piagetian mediation practitioners it is important to enable and encourage the transfer and application of knowledge and skills.

We conceptualised mediation according to the widely known perspective of Reuven Feuerstein (Feuerstein & Feuerstein, 1991; Feuerstein et al, 2010). We argue that this theory combines the theories on mediated learning, as it departs from the premise that the teacher should initially play a dominant role in purposefully mediating cognitive tools, but gradually shifts towards self-mediation, where the learner has to start working independently from the mediator, appropriating the tools and using them. A learner deprived of initial, purposeful teacher-initiated mediated learning opportunities might continue to respond in an unsystematic, disorganised and even chaotic approach to learning, not learn rapidly when exposed to new experiences and will not be able to modify their performance in flexible and adaptable ways (Deutsch 2003).

To round off this section of the article, we reflect on the premise of Reuven Feuerstein's theory of mediated learning. Although there are limitations to his views, there is much one can take from his ideas about, "structural cognitive modifiability". According to his theory, deficient or fragile cognitive processes in children can be modified through an interactive process of mediation that is directed at what some would refer to as 'self-direction' (Feuerstein et al 2010). The notion of "cognitive modifiability" goes beyond the idea of the learning of fixed sets of facts, rules and procedures, but emphasises the development of essential skills, strategies and dispositions that are critical to transforming ways in which learners interact with others, how they approach learning, how they deal with cognitive challenges and how they can become more confident and motivated to learn and achieve (Bransford 2010:xii). Fitzpatrick (2012) would refer to this as executive functions training. There is agreement in the literature that once the essential skills, strategies and dispositions are fixed, they should be kept intact by structuring learning environments that support the continuous growth of the skills, strategies and dispositions (Bransford 2010:xii).

Method

Research framework

As the purpose of this research was trying to solve a problem that required an integrated understanding of different types of data, a pragmatic research framework that combines the collection of quantitative and qualitative data was utilised. We

collected quantitative test data of children's application of cognitive and metacognitive skills and strategies in their grade R year. We also gathered qualitative observation data on the nature and quality of the participants' executive functions in the input, elaboration and output phases of the learning process.

Participants

Due to time and logistical constraints involved in conducting a postgraduate study, as well as the intensive nature of the mediated learning approach, we involved one willing grade R class with twenty learners from a primary school in a town in the Free State province. All the learners in the grade R class were involved in the pretest. Based on the pretest results, we identified the sample, which comprised ten learners who were purposively selected based on their test performance and randomly assigned to experimental group A or B (both numbering 5 learners each).

The sample was heterogeneous regarding gender and more or less homogeneous regarding pretest performance, socio-economic background (middle-class), ethnicity and culture (white, Afrikaans speaking) and age. The selection of the participants was made as follows: Four learners who obtained the highest pretest scores (four males), four learners who obtained average pretest scores (four females), and two learners who obtained the lowest pretest scores (two males).

In each of the performance groups, two learners were randomly allocated to an experimental A and an experimental B group, except the learners who obtained the lowest pretest scores. In this group, only one learner was allocated to the experimental A and experimental B groups respectively, as they appeared to need more intensive, individual mediation than the other learners did. Both experimental groups, on rotational basis, received the intervention in pairs, and therefore we purposively selected learners who had more or less the same achievement level in the first pretest to form groups. Consistent with the view of Benjamin (2006), we chose to work with a small sample, as it is argued to be more beneficial for administering cognitive development programmes intensively. Moreover, the learners were very young and not familiar with a mediated learning approach, and we aimed to give each learner intensive, individual attention during the intervention.

Research procedure

Similar procedures guided the administering of the various test sessions. No mediation was given during the test occasions, except for minor focusing and regulation of behaviour. The post-test was administered directly after the implementation of the intervention in order to examine cognitive improvement and the effects of the mediational approach (Tzuriel 1990).

The quantitative study can be described as a small quasi-experiment, and the qualitative part as an observation study, comprising observations in the form of structured running and anecdotal records. The observations took place during the test occasions, as well as during the implementation of the intervention. The first author

was the observer. Before the pretest was administered, all learners in the class (n = 20) individually participated in the pre-teaching phase. We acquainted them with concepts and vocabulary in the test, after which they completed the pretest individually. Experimental group A was exposed to the intervention at the beginning of the school year in January for 12 weeks, while experimental group B received normal class teaching. Experimental group A then wrote the post-test to determine the impact of the intervention on their cognitive functioning. Experimental group B also wrote the post-test to determine if normal class teaching influenced their cognitive functioning in any way. Experimental group A then received normal class teaching for 12 weeks, while experimental group B received the intervention. Both groups then completed post-test 2 to establish the impact of the intervention on the cognitive functioning of group B. Four months after completion of the research, both groups completed a delayed post-test to determine whether retention of enhanced cognitive functioning took place. Pretest 2 was written after the three weeks school holiday in July to determine any cognitive changes in the absence of mediation (group A) and normal classroom teaching (group B).

The intervention

The learning outcomes for grade R learners in South Africa guided the development of the intervention activities. The activities focused on the application of the following executive functions: Paying attention, remembering, becoming flexible in applying skills and strategies for interpreting, classifying, categorizing, comparing, analysing, problem-solving, evaluating, inferring and deducing, imagining, critical evaluation and reflection (Department of Education, 2002; Department of Basic Education, 2011). The aforementioned skills and strategies corresponded well with the skills and strategies the learners had to apply in the Children's Inferential Thinking Modifiability (CITM) test. We designed the intervention by keeping the criteria for mediated learning and the key elements for improving the executive functions of grade R learners as identified by Papalia, Wendkos Olds and Duskin Feldman (2008), Patterson (2008) and Van Staden (2005) in mind. Participants had to categorise shapes according to colour and size on their own, and motivate their categorisations. Categorisation promoted the application of cognitive *and metacognitive skills and strategies* such as comparing, classifying, categorising and problem-solving, reflection, interpreting and evaluation. *Perception activities* focused on concepts of time and direction, similarities and differences, spatial relations and auditory perception and discrimination. As advocated by mediated learning theory, *active and interactive involvement* was central to all the learning activities. Learners were requested to walk, crawl and hop on shapes to determine the characteristics of shapes, manipulate shapes and form various shapes with pieces of string. *Transfer activities* expected of participants to apply principles, rules and strategies acquired during the intervention to new and similar tasks. Verbal and numerical *problem-solving* activities involved the application of *conservation* skills by manipulating objects such as unifix blocks, counters and parts of shapes, which had to be arranged to form wholes. Mastering *basic concepts* involved

in identifying size, length, position or shape, were included in the intervention. *Number concept* activities developed simple adding and subtraction strategies by using various counters. Participants were confronted with *scientific concepts* related to their world of experience, for example people, animals, plants, seasons and the weather, as well as spatial relations. *Memory* and creative thinking strategies were attended to throughout the intervention. Not only were participants expected to remember concepts, rules, principles and strategies, they also had to remember the categorisation of 24 pictures according to different types of animals, transport, shapes, plants, clothing and furniture. Participants were continuously encouraged to *reflect* on their responses in order to correct their own mistakes, and become aware of their own thinking. *Language* development involved listening to instructions, explaining answers, communicating thoughts, identifying letters, rhyme words, and beginning, middle and end sounds of three-letter words. *Symbolic thought* was encouraged by asking the participants to create representational drawings.

Throughout the intervention, attention was paid to advancing inhibitory control functions such as increasing frustration tolerance, experiencing delight in successful task completion, nurturing feelings of competence, eliminating fear of failure and encouraging the need for mastery (Feuerstein 2007).

The test and intervention sessions took place early in the morning, between 8:00 and 9:00, in a quiet, familiar classroom at the school of the participants.

Data collection

The CITM test involves a dynamic assessment (test-teach-test) procedure that attempts to assess learning strategies and accessibility to mediation, the utilisation of higher-order concepts and operations and the application of a variety of cognitive and metacognitive skills and strategies to solve problems. The teaching phase took place during the implementation of the intervention. The pretest phase followed after the participants were presented with example problems similar to those in the test, and the basic rules and strategies of solving inferential problems were clarified. The CITM test comprises twelve figural problem-solving "sentences" where participants had to determine the correct place of different picture objects. The solving of the problem "sentences" required systematic, exploratory behaviour, control of impulsivity, spontaneous comparative behaviour, planning, inferential hypothetical thinking, inductive reasoning and concurrent consideration of more than one source of information (Tzuriel 2001:82). We utilised the measurement/research version of the CITM. A score of 1 was given for a correct answer and no score was given for an incorrect answer. A gain score was then computed by deducting the score of the pretest from the score of the post-test (Tzuriel 2001:66–67).

Both researchers acted as observers during the administering of the CITM and the implementation of the intervention. One of the researchers administered the CITM and implemented the intervention and therefore participated as observer. This researcher became part of the intervention in an attempt to improve the cognitive development of the participants. The intense nature of her involvement allowed for

the utilisation of anecdotal records of all behaviour or events related to the cognitive functioning during the input, elaboration and output phases of the learning process, as well as strategies for inhibitory control which each participant displayed. The other researcher acted as a complete observer who compiled structured, detailed, continuous and chronological accounts of individual participants' behaviour in relation to predetermined criteria linked to the application of cognitive and metacognitive skills and strategies, as well as executive functions as they occurred. The structured running records and the anecdotal records were compared and conclusions made based on the interpretation of both sets of records.

Rigour

The current authors received training in the principles of dynamic assessment and the application of the CITM. The CITM can be presented to diverse groups of multicultural learners in mainstream education (Tzuriel, 1990; Tzuriel, 2001). The clinical and empirical validity of the CITM have been established by Benjamin (2006) and Tzuriel (2000 and 2001). Previous assessments measured Cronbach alpha coefficients of .85 and .89 respectively (Tzuriel 2001:82).

We ensured prolonged engagement by staying in the field until data saturation occurred, and guaranteed referential adequacy by utilising structured observation in the form of running and anecdotal records. Predetermined criteria that guided our observations ensured objective and selective attention to the learners' actions. We observed the nature and quality of change regarding the participants' application of executive functions in terms of retention, resistance, flexibility and generalisability (Feuerstein et al 2002:526–530).

We found peer briefing helpful where we spoke to knowledgeable colleagues in the field with whom we reviewed our insights and analyses. Member checks were continuously done to correct obvious errors in our findings.

Ethical issues

We obtained permission from the Free State Department of Education, the principal of the school and the teachers and parents of the grade R learners. Participants, their parents, the teachers and the principal were informed about the aim and process of the research, why certain learners were chosen to take part in the research, as well as the possible benefits the research holds for the learners. All results were dealt with confidentially and no names were attached to participants in the writing up of the research findings.

Results

The CITM test results focused on the participants' application of cognitive and metacognitive skills and strategies when confronted with problem-solving tasks. The analysis of the group data focuses on a comparison of test results between and within each of the experimental groups A and B, by means of the Wilcoxon signed-rank test.

Quantitative data analysis

Table 1 compares the mean ranks for the test results of experimental group A and B to determine whether the differences noted between the two groups were statistically significant. According to Leech, Barrett and Morgan (2005:59), if the difference between means was not statistically significant, it is best not to make any comment about which mean was higher, because the difference could be due to chance. Likewise, if the difference was not significant, Leech et al (2005) recommend that effect size is not discussed or interpreted.

Table 1: Differences between test results for experimental group A and B

Group	*n*	*Mdn*	*SD*	Mean rank	Mann-Whitney U	Z	*p*	*r*
Pretest 1								
A	5	17	5.36	6.600	7.000	-1.152	0.249	-
B	5	14	3.64	4.400				
Post-test 1								
A	5	30	10.35	7.000	5.000	-1.571	0.116	-
B	5	12	2.58	4.000				
Pretest 2								
A	5	24	10.27	7.600	2.000	-2.193	0.028*	0.693
B	5	10	7.41	3.400				
Post-test 2								
A	5	35	12.15	6.90	5.500	-1.471	0.141	-
B	5	25	2.54	4.10				
Delayed post-test								
A	5	34	11.45	5.90	10.500	-.124	0.671	-
B	5	30	2.88	5.10				

Note: Statistical significance: $p < 0.05$

Only the pretest 2 results revealed a statistical significant difference between group A and B, as $p < 0.05 = 0.028$, $r = 0.693$. We argue that group A obtained the better result after the intervention, which implies that the intervention contributed to improving the application of the cognitive and metacognitive skills and strategies of group A. Pretest 2 was completed three weeks after the completion of the intervention, and we believe that group A retained the cognitive and metacognitive skills and strategies that they acquired during the intervention.

Although group B also benefited from the intervention (see table 3), no statistical significant difference between the post-test 2 results of group A and B, $p > 0.05 = 0.141$, was noted. Post-test 2 was written after the intervention with group B, and although

both groups benefited from the intervention, one group did not seem to benefit more from the intervention than the other group. The delayed post-test results of both groups showed improvement in comparison to their pretest results, but without a statistical significant difference between the two groups, $p > 0.05 = 0.671$. Moreover, the results of both groups did not indicate a decline in performance.

No statistical significant difference was evident between the pretest results, which confirms that the groups were equally effective in applying cognitive and metacognitive skills and strategies at the onset of the study, $p > 0.05 = 0.249$.

There was no statistical significant difference between the results of post-test 1, $p > 0.05 = 0.116$. Although experimental group A had received the intervention, statistically they did not do significantly better than experimental group B, who only received normal class teaching, as indicated by the comparison of the post-test 1 results.

The large standard deviations noted for experimental group A can be linked to the poor performance of one of the participants, participant 5, whose results could be regarded as outliers.

Table 2 compares the differences between the pre- and post-test results within experimental group A.

Table 2: Comparison of differences between test results within experimental group A

			Mean rank				
	n	***Mdn***	**Negative**	**Positive**	**Z**	***p***	***r***
Post-test 1	5	30	.000	3.000	-2.032	0.042*	0.643
Pretest 1	5	17					
Pretest 2	5	24	.000	3.000	-2.032	0.042*	0.643
Pretest 1	5	17					
Post-test 2	5	35	.000	2.50	-1.841	0.066	-
Pretest 1	5	17					
Delayed post-test	5	34	.000	3.000	-2.023	0.043*	0.640
Pretest 1	5	17					
Pretest 2	5	24	5.000	2.500	-.677	0.498	-
Post-test 1	5	30					
Post-test 2	5	35	1.000	3.500	-1.753	0.080	-
Post-test 1	5	30					
Delayed post-test	5	34	1.000	3.000	-1.461	0.144	-
Post-test 1	5	30					

			Mean rank				
	n	***Mdn***	**Negative**	**Positive**	**Z**	***p***	***r***
Post-test 2	5	35	1.750	3.250	-.552	0.581	-
Pretest 2	5	24					
Delayed post-test	5	34	1.500	3.500	-.730	0.465	-
Pretest 2	5	24					
Delayed post-test	5	34	2.500	2.500	.000	1.000	-
Post-test 2	5	35					

Note: Statistical significance: $p < 0.05$

Statistical significant differences occurred between post-test 1 and pretest 1, $p < 0.05 = 0.042$, $r = 0.643$. The participants performed better in post-test 1 than in pretest 1, and we concluded that the intervention contributed to this statistical significant difference.

Pretest 2 yielded better results than pretest 1, with a statistical significant difference of $p < 0.05 = 0.042$, $r = 0.643$. Pretest 2 was written after the intervention and after post-test 1, and the improvement in the pretest 2 result implied that the initial improvement in the application of cognitive and metacognitive skills and strategies acquired during the intervention noted in the post-test 1 result was retained.

The participants performed better in the delayed post-test than in pretest 1, with a statistical significant difference, $p < 0.05 = 0.043$, $r = 0.640$. Moreover, this result confirmed that the statistical significant improvement noted between pretest 1 and post-test 1, after the implementation of the intervention, was retained in the absence of mediation.

No statistical significant differences were noted between pretest 1 and post-test 2, post-test 1 and pretest 2, post-test 1 and post-test 2 and between pretest 2 and post-test 2. A possible explanation for this observation could be that prolonged exposure to practice and application of the cognitive and metacognitive skills and strategies that were acquired during the intervention is needed to contribute to further statistical significant improvement in the application of the skills and strategies. Before post-test 2, the participants had 12 weeks exposure to normal classroom teaching, during which they could apply the skills they acquired in the intervention. The time might not have been adequate to contribute to statistical significant improvement in the application of the skills and strategies during post-test 2. The same argument might be true for the absence of statistical significant differences between pretest 2 and the delayed post-test, post-test 1 and the delayed post-test and between the delayed post-test 1 and post-test 2. It is noteworthy that in the four months absence of normal class teaching and mediation, the application of the skills and strategies that were improved during the intervention were retained.

Table 3 below summarises the differences between pre- and post-test results within experimental group B.

Table 3: Comparison of differences between test results within experimental group B

	n	*Mdn*	Mean rank		Z	*p*	*r*
			Negative	Positive			
Post-test 1	5	12	2.500	3.330	-.677	0.498	-
Pretest 1	5	14					
Pretest 2	5	10	3.130	2.500	-1.361	0.174	-
Pretest 1	5	14					
Post-test 2	5	25	.000	3.000	-2.041	0.041*	0.645
Pretest 1	5	14					
Delayed post-test	5	30	.000	3.000	-2.023	0.043*	0.640
Pretest 1	5	14					
Pretest 2	5	10	3.330	2.500	-.677	0.498	-
Post-test 1	5	12					
Post-test 2	5	25	.000	2.500	-1.826	0.680	-
Post-test 1	5	12					
Delayed post-test	5	30	.000	3.000	-2.023	0.043*	0.640
Post-test 1	5	12					
Post-test 2	5	30	.000	3.000	-2.023	0.043*	0.640
Pretest 2	5	10					
Delayed post-test	5	30	.000	3.000	-2.023	0.043*	0.640
Pretest 2	5	10					
Delayed post-test	5	30	.000	3.000	-2.023	0.043*	0.640
Post-test 2	5	25					

Note: Statistical significance: $p < 0.05$

The participants performed better in post-test 2 after the implementation of the intervention than in pretest 1. This difference was statistically significant, $p < 0.05 = 0.041$, $r = 0.645$. We concluded that the intervention contributed to this statistical significant difference.

The difference between the delayed post-test and pretest 1, resulted in a statistical significant difference, $p < 0.05 = 0.043$, $r = 0.640$, related to effectiveness and efficiency with which the participants applied cognitive and metacognitive skills and strategies during the delayed post-test. We argue that the intervention contributed to the effectiveness and efficiency of the improvement noted in the application of cognitive and metacognitive skills and strategies. Moreover, the statistical significant difference noted between pretest 1 and post-test 2, after the implementation of the intervention, was retained.

The difference between the delayed post-test and post-test 1 indicated a statistical significant improvement in the delayed post-test, $p < 0.05 = 0.043$, $r = 0.640$, which we contribute the improvement to the intervention programme. More importantly, the result confirmed the retention of the skills and strategies acquired during the intervention in the absence of mediation.

The participants performed better in post-test 2 than in pretest 2, with a statistical significant difference of $p < 0.05 = 0.043$, $r = 0.640$. Post-test 2 was written after the intervention, and the results confirm that the improvement that was noted can be linked to the implementation of the intervention.

We noticed a statistical significant improvement, $p < 0.05 = 0.043$, $r = 0.640$, in the application of cognitive and metacognitive skills and strategies of the participants in the delayed post-test as compared to pretest 2 (before the intervention). Remarkably, the statistical significant difference noted between pretest 2 and post-test 2 after the implementation of the intervention was retained.

The participants performed better in the delayed post-test than in post-test 2, with a statistical significant difference, $p < 0.05 = 0.043$, $r = 0.640$. Furthermore, this result led us to believe that the statistical significant difference noted between pretest 1 (before the intervention) and post-test 2 (after the intervention) was retained in the absence of direct, purposeful mediation.

No statistical significant differences were noted between post-test 1 and pretest 1, pretest 2 and pretest 1, and pretest 2 and post-test 1. We concluded that the 12 week classroom teaching that preceded post-test 1 and pretest 2 apparently did not provide purposeful opportunities for the development and application of cognitive and metacognitive skills and strategies. We are unsure as to why no statistical significant difference was noted between post-test 1 (before intervention) and post-test 2 (after intervention). One possible explanation might be that this group of participants required more than 12 weeks to become effective in the application of the cognitive and metacognitive skills and strategies. Our argument might hold true if the statistical significant difference between the delayed post-test and post-test 1 is considered. In the four months absence of mediation the application of the skills and strategies in everyday situations possibly aided their retention.

Qualitative data analysis

With the observations we established whether the intervention also improved the effectiveness and efficiency with which the participants processed information during the input, elaboration and output phases of the learning process.

We analysed the data using deductive as well as inductive approaches, and linked the interpretations to a 9 point scale that depicts the extent and nature of required mediational intervention (RMI), on a continuum from 0–9, to generate maximum cognitive modifiability or change (Feuerstein et al 2002). It was important to establish whether the intervention enabled learners to move from dependency on a mediator (levels 1–3), to average levels of dependency (levels 4–6), to autonomy during the execution of learning tasks (levels 7–9).

Observations: Input phase

Table 4 reports on the observation results for the ten participants at the onset of the research and after the intervention process.

Table 4: Input phase

	RMI: Pre-intervention									
Participant	1	2	3	4	5	6	7	8	9	10
RMI level	0	0	2	0	0	0	0	0	0	0
	RMI: Post-intervention									
Participant	1	2	3	4	5	6	7	8	9	10
RMI level	6	6	9	8	1	7	6	9	6	4

During the pretest, the participants lacked systematic thinking behaviour and precise and accurate working methods. The verbal receptive tools to gather, process and express information were not intact, manifesting in a lack of precision and accuracy in completing tasks. Participants worked impulsively, which resulted in activities completed incorrectly. Our observations indicated that the executive functions in the input phase appeared to be emerging, and that the learners are not ready to respond effectively to cognitive learning tasks.

As the intervention progressed, the participants started to react more quickly to a stimulus and considered different possibilities for solving problems. They used tracking and visual scanning to determine answers. During the post-test and delayed post-test, all the participants, except participant 5, progressed and were able to reflect on their answers and make corrections on their own. Although impulsivity characterises the working ways of young learners (Lerner 2006), our observations correlate with Feuerstein's opinion (in Lerner, 2006; Tzuriel, 2001) that a mediator can replace a learner's impulsive working ways with self-regulation that involves planned, systematic and comparative behaviour (Feuerstein et al 2010).

It appears as if the processing of information in the input phase improved among the participants, as the degree of RMI progressed from high to low. In addition, they

appeared to be more able to apply cognitive and metacognitive skills and strategies without assistance. More importantly, we noticed some permanence of change and more control and flexibility in the participants' ways of working. They were better able to apply newly acquired functions to wider contexts (Feuerstein et al 2002).

Observations: Elaboration phase

Table 5 summarises the observation results for the ten participants before and after the intervention process.

Table 5: Elaboration phase

	RMI: Pre-intervention									
Participant	1	2	3	4	5	6	7	8	9	10
RMI level	0	0	2	0	0	0	0	0	0	0
	RMI: Post-intervention									
Participant	1	2	3	4	5	6	7	8	9	10
RMI level	7	7	9	7	2	6	6	6	6	4

Initially, the participants could not identify a starting point or cue when solving problems and did not work according to rules. They could not distinguish between what was relevant or irrelevant to the task they had to complete and often provided poor or no responses to tasks. We concluded that their spontaneous comparative behaviour and planning strategies were apparently still emerging. At times, the participants were eager to complete activities and made mistakes, because they did not reflect on their answers. This observation concurs with the literature that emphasises the emergent nature of metacognition in the young learner between the ages of four and six (Botha, 2003; Robson, 2006). During the course of the intervention, participants started to select relevant information in order to solve a problem, and compared options before deciding on a final answer. It seemed that purposeful mediation taught the learners to become more effective in processing information, sequencing steps in learning and moving from dependent and concrete learning to more independent and abstract learning (Feuerstein et al 2010).

Effective processing of information in the elaboration phase also appeared to be emerging. We noticed some permanence in the changes that took place regarding the restraining of impulsivity, flexibility to change and adapt to new task demands and the application of the emerging cognitive functions to wider contexts (Feuerstein et al 2002:526–527), except for participant 5.

Observations: Output phase

In table 6, we report on the observation results for the ten participants before and after the intervention process.

Table 6: Observations: Output phase

	RMI: Pre-intervention									
Participant	1	2	3	4	5	6	7	8	9	10
RMI level	0	0	3	3	0	1	0	0	0	0
	RMI: Post-intervention									
Participant	1	2	3	4	5	6	7	8	9	10
RMI level	7	7	9	6	1	8	6	9	6	6

Initially, many of the participants demonstrated egocentric behaviour, which could be linked to the fact that they were still very young (Papalia et al 2008). They could not separate the task from their own world of experience, and had to be reminded to focus on the task. The participants experienced problems with internalising visual changes of directions, relations and connections. As the intervention progressed, they became more skilled in recognising relations among objects, like similarities and differences, for example.

Because the participants lacked precise and accurate working methods during the input phase at the onset of the study, trial and error behaviour, impulsivity and inadequate communication of solutions to problems initially characterised their mental activity in the output phase. Not one of the participants, except participant 5, demonstrated blocking behaviour (rejecting the mediator's attempts to teach) and an inability to respond. We carefully concluded that the strategies to process information in the output phase were not yet fully developed and therefore did not manifest in observable ways.

Except for participant 5, all of the participants who initially required a high degree of RMI (levels 0–3) appeared to become more autonomous and independent in formulating their own rules and working strategies during the course of the intervention.

Observations: Inhibitory control factors

In table 7, we report on the observation results specifically for the inhibitory control functions before and after the intervention process.

Table 7: Non-intellective factors

	RMI: Pre-intervention									
Participant	1	2	3	4	5	6	7	8	9	10
RMI level	1	1	5	5	0	5	0	4	3	3
	RMI: Post-intervention									
Participant	1	2	3	4	5	6	7	8	9	10
RMI level	8	8	9	8	1	9	6	9	7	4

Initially, the participants needed a lot of motivation to persevere and their attention spans sometimes fluctuated. A high level of attentiveness and interest was absent during the completion of tasks, and we undertook purposeful efforts to enhance their interest and attentiveness by working on concrete and authentic tasks. Only four of the participants, participants 3, 4, 6 and 8, who appeared to be functioning at a moderate RMI level (levels 4–6), seemed to have some previously learned strategies and rules available for dealing with emotional, motivational and attitudinal aspects related to learning.

Participants had to be encouraged to persist and to complete activities successfully. Often frustration was present when participants experienced problems in the completion of challenging tasks. Through mediation, we aimed to encourage their intrinsic motivation and persistence by requesting them to keep on trying and highlighting the importance of being successful in task completion. Throughout the intervention, their independence emerged and they became more aware of their own thinking, and prepared to take on challenging tasks. Their determination to complete tasks and to correct their own tasks increased, which could be regarded as a sign of intrinsic motivation emerging.

The participants never rejected meditational attempts or withdrew from learning, except for participant 5, who demonstrated extreme blocking behaviour (rejecting the mediator's attempts to teach) and an unwillingness to become involved in activities. It could be that this participant's passivity and lack of attentiveness and interest could be related to fear of failure or negative learning experiences encountered in the past (Tzuriel 2001). Participant 5 displayed no perseverance, and could not work independently. Sometimes he did not even want to try working on a task. He preferred practical work, where he could manipulate objects, but wanted to complete tasks on his terms and did not care if he completed the tasks correctly or not. His attention fluctuated and he sometimes got aggressive if things did not go his way, therefore exhibiting a low frustration tolerance. He clearly wanted to avoid tasks involving academic demands. At the end of the study, seven participants were observed as being at levels 7–9 in terms of their RMI to deal with emotional, attitudinal and motivational factors during learning. A change in the nature and extent of mediation required was noticed. An increase in learner autonomy and a decrease in depending on the mediator was noticed (Feuerstein et al 2002).

Throughout the intervention, progression was noted in terms of the participants' actions which were initially very mediator-dependent, but became more spontaneous.

Discussion

The research findings highlight the practical benefits of the specific mediated learning intervention with a sample of grade R learners. There is evidence of enhanced cognitive functions that benefitted the application of cognitive and metacognitive skills, and that eliminated motivational-affective factors that can influence learning and achievement. Our research extends previous research by suggesting a novel

approach to teaching grade R learners that infuses the teaching of thinking directly into subject content and does not treat it as an additional add-on to the curriculum.

The statistically significant improvement noted in the application of cognitive and metacognitive skills and strategies confirms that the intervention had improved the cognitive flexibility of the participants and contributed to the improvement in test results. This observation is consistent with Feuerstein's theory that mediation enables learners to know how to select and focus on relevant stimuli, become more responsive and ultimately to benefit from learning (Feuerstein 2007; Feuerstein, Klein & Tannenbaum, 2005; Fraser, 2006; Haywood, 1994; Peña, Gillam, Malek, Ruiz-Felter, Resendiz, Fiestas & Sabel, 2006). The mediated learning approach with young learners provided opportunities for enhancing the learners' ability to sequence events and steps in problem-solving, nurtured transcendence from dependent and concrete learning to independent, abstract learning, improved the manipulation of symbols and words, and increased the ability to describe concepts and words (Feuerstein 2010:272–273). From the research findings we conclude that mediated learning transformed the ways in which the learners approached learning, dealt with cognitively challenging tasks and influenced their becoming more confident and motivated to learn and achieve.

Throughout the intervention, it appeared that the participants' *need for mastery* improved, thus supporting Benjamin (2009:2), Feuerstein (2007:23–24) and Tzuriel (2001:50–55, 72–73), who report on the importance of mediation to improve inhibitory control. The need for mastery and determination to complete tasks successfully developed throughout the intervention and could have been present in the subsequent test occasions, which contributed to the progressive improvement noted in the test results. The participants' planning of their work improved, confirming the findings of Feuerstein (2007) and Lomofsky (2007), which state that mediated learning will decrease anxiety to fail and enable learners to develop strategies, search for alternative answers and work in a more systematic manner. The participants adopted a more planned way of work, which they possibly transferred to the test situation and may have contributed to the improvement in the results.

Our initial observations correlate with what Benjamin (2009:2), Feuerstein (2007:23–24) and Tzuriel (200150–55, 72–73) affirm, namely that emergent or deficient executive functions manifest as unplanned and impulsive behaviour. This could be reversed to systematic behaviour through mediation, and therefore supports Feuerstein's theory of cognitive modifiability (Feuerstein et al 2010). Furthermore, our findings confirm the establishment of thinking behaviour due to mediation that ensures self-regulation, remembering the application of rules, principles and strategies, which contribute to diminishing impulsivity in the learner (Lerner, 2006; Lerner & Johns, 2009; Tzuriel, 2001). Another striking finding that emerged from our observations supports Feuerstein's view that impulsive, emotional reactions can be reinstated by logical, objective and more controlled responses due to mediation (Feuerstein 2007).

We deduce from the observations that it was possible to teach the learners to become more effective in processing information through a process of mediation (Feuerstein et al 2010). Throughout the observations the participants' efficiency level, as well as precision and energy, improved remarkably. Participants also worked in a more controlled manner and were more flexible in applying learnt strategies and rules to wider contexts, which possibly contributed to the progressive improvement noted in the various test results of the participants. Extreme impulsive behaviour was reduced and flexibility to change was evident (Feuerstein et al 2002).

The learners who took part in the study started to internalise the cognitive and metacognitive skills, strategies and functions mediated to them, and these apparently became integrated mechanisms of change within the learners (Benjamin, 2005; Tzuriel, 2001). Learners became able to use the familiar to interpret the unfamiliar (Lidz, 2003; Tzuriel, 2001), and their willingness, enthusiasm and persistence to continue with challenging work increased (Deutsch, 2003; Feuerstein 2007). Learners became more able to assess and reflect on their own progress and change (Deutsch, 2003; Feuerstein et al, 2010). Our findings confirm that mediated learning supports the development of learners who are autonomous, confident and in control of their own learning (Lerner, 2006; Lomofsky, 2007).

The participants performed better on recognition than on recall, which is in line with what literature declares regarding preschoolers' memory ability (Papalia et al, 2008; Patterson, 2008). The more familiar participants became with the objects and problem-solving strategies they used during the intervention, the better they recalled them.

Mediated learning appeared to be effective for enhancing all three dimensions of executive functions, namely, working memory, inhibitory control and cognitive flexibility. In the case of participant 5, we argue that his poor verbal skills, inadequate visual motor and visual perception abilities could have contributed to the problems he experienced with cognitive functions in the input, elaboration and output phases of the mental act.

Based on the data, we reject H_o and accept H_a[1] due to the statistically significant differences in the pre-, post- and delayed post-test results after the implementation of the intervention within both experimental groups A and B. The intensive nature of the mediated learning approach during the intervention, the individual attention and support given to participants, and the numerous opportunities for nurturing the executive functions that positively influenced the application of cognitive and metacognitive skills and strategies, and reduced the negative influence of motivational-affective factors, possibly contributed to the improvement in the cognitive development of the learners. An interesting finding that emerged is that once cognitive and metacognitive skills, strategies and cognitive functions become fixed, they are retained over time.

Limitations

It is possible that other results could have been different if the intervention was implemented over a longer period than 12 weeks. We acknowledge that the experience that we gained during the implementation of the intervention with experimental group A could have advantaged group B and influenced the outcome of their post-test results.

The CITM test could have posed a limitation to the research for learners who prefer verbal to visual learning, especially during the test phase, where no mediation is provided and verbal interaction is absent.

Aspects such as motivation, maturation, concentration and the implementation of the intervention in two separate sessions could have influenced the results. In addition, the intervention might have been more effective with individuals, as group work can pose disadvantages to progress and achievement.

The small geographically and culturally bound sample complicated the generalisation of the results, and the research design is only suitable for the formulation of tentative hypotheses.

Conclusion

This study aims to be a first step toward new research opportunities involving controlled, true-experimental studies with larger, diverse groups of participants to claim conclusively that the mediated learning improves cognitive development in grade R.

The research findings add to a growing body of research examining the impact of additional curricular interventions to improve cognitive development in grade R. In particular, our research findings alert teachers to the effectiveness of mediated learning as a novel curriculum-based teaching approach with preschool learners. Furthermore, mediation seems to be indispensable for enhancing the executive functions that are fundamental to the application of cognitive and metacognitive skills and strategies when processing information. Mediated learning provides learners with learning opportunities that are dynamic and supportive, and fosters continued engagement in learning that leads to sustainable and ongoing independent learning (Bransford 2010:xii).

In order for learners to perform better academically and to acquire important skills, their cognitive development should be purposefully nurtured as early as grade R. Early identification of cognitive difficulties can lead to early intervention, which in turn could decrease and even prevent failure at school.

Although our research was conducted on a small scale, we argue that it is important for international reading to attract potential research in other similar and dissimilar contexts related to the under-researched field of mediated learning with grade R learners.

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