THE EFFECT OF DIFFERENTIATED TEACHING ON LEARNER ACHIEVEMENT OF GRADE 8 MATHEMATICS LEARNERS WITH SPECIAL EDUCATIONAL NEEDS

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ABSTRACT

This paper intend to address the effect that differentiated teaching in a learning centre has on learner achievement of grade 8 mathematics learners with special educational in a private inclusive school in Gauteng. The purpose of differentiated teaching is to provide quality teaching regardless the problem experienced of meeting a wide range of learning needs among grade 8 mathematics learners in an inclusive classroom. A pragmatic philosophy was adopted aiming at finding a solution to this problem. A quantitative research design was used with one data collection methods, namely analysis of assessment results. The whole population of 48 learners, in two equal classes, was conveniently selected for the sample. The assessment results reveal that the learning centre yielded success as far as content knowledge is concerned. However, this finding is not conclusive, for the learners did not excel in problem solving skills. In order for a learning centre to be effective, it should meet learners at their current level of understanding. The paper adds to research on Inclusive Education in South Africa.

Key words: Differentiated teaching; learning centre; mathematics; special educational needs; learner achievement.

1. INTRODUCTION AND BACKGROUND

This paper intends to evaluate the effect of differentiated teaching on learners' achievement in a learning centre within a grade 8 mathematics class for learners with special educational needs in a private inclusive school in Gauteng. In July 2001, the South African Education Department implemented White Paper 6 on Inclusive Education, which aimed for the development of a single education system to provide quality teaching that would cater for a "full range of learning needs among all learners" (Department of Education, 2001, p.11). Thus, the initiative aimed at

moving away from the segregation of learners with barriers in special needs school towards the inclusion of these learners within mainstream schools (Pottas, 2005, p.58).

Tomlinson (2000, p.1) defined differentiated teaching as a "tailoring teaching to meet individual needs", whilst for Laturnus (2010, p.50) it was a "necessary strategy" for planning teaching experiences that accommodate the needs of each learner. In particular, differentiated teaching offers learners multiple options for processing new information and making sense of ideas, so that all can effectively acquire new knowledge despite differences in cognitive abilities (Tomlinson, 2001).

Learning centres are areas set up around the room and designed for a specific activity, with learners focusing on developing a particular skill or concept while working either individually or in cooperative groups. More specifically, a learning centre for mathematics provides additional support for learners who have mathematical difficulties (Fuller, 2002).

According to Engelbrecht and Green (1999, p.6) inclusion is "a shared value which promotes a single system of education dedicated to ensuring that all learners are empowered to become caring, competent and contributing citizens in an inclusive, changing and diverse society". In addition, an inclusive school provides education for all learners "regardless of differences in respect of race, class, culture, language, gender, ethnicity, ability or disability" (Ngcobo & Muthukrishna, 2011, p.357). In this paper I refer to an inclusive school as an institution that provides education for all learners who can cope in a mainstream school despite their physical, affective or social handicaps.

This study is based on problems experienced in accommodating all learners' educational needs in a single classroom in the wake of the inclusive educational reform policy of South Africa. According to Donald, Lazarus and Lolwano (2006), "teachers should always be searching for more effective ways of connecting with their student's learning processes" (p.50). By redesigning effective, differentiated learning episodes, teachers can deliver content in a way that leads to active learning, despite differences in learners' abilities. Gardner (2003) argued that one of the greatest mistakes made in past centuries in education is that children were treated as

though they were all variations of the same individual. Therefore, he called for new ways of teaching and learning. Within the context of an inclusive educational system, change needs to occur, which should influence all teaching strategies that are utilised.

DI for learners with special educational needs

In the 1990s DI for learners with SEN was high priority in England and Wales, especially with the introduction of universal education in 1972. In particular, in-service material was devoted to differentiation (Barthorpe & Visser, 1991; Devon, 1992; Elliot, Mills, Stephenson & Underwood, 1992; Wiltshire, 1992). Furthermore, several studies were conducted during this period. Bennett, Deforges, Cockburn and Wilkinson (1984) investigated the quality of learners' learning experiences in primary schools and maintained that differentiation is not fully understood by teachers and takes place in less than half of the classrooms they have observed. According to them the lack of differentiation leads to teachers focusing only on quantity of work instead of quality of work, and thus, an underestimation of what learners can achieve. Simpson, Cameron, Goulder, MacPherson, Duncan, Roberts and Smithers (1989) studied differentiation in six Scottish primary classrooms. Their research established that there was a considerable mismatch between what teachers intended a task to do and how pupils experienced the task. Fuchs, Fuchs and Bishop (1992) identified conditions which prompt teachers to change their style of teaching and found that teachers within secondary schools rarely questioned or adapted their teaching styles in relation to learners' achievements except when teaching learners perceived as having SEN. Biggs (1993) examined students' learning processes and differentiation within higher education and claimed that students learning styles and achievements seldom impact on the teaching styles adopted by tutors. Simpson and Ure (1993) studied differentiation within secondary schools. They found that differentiation, particularly in mathematics, was conceived in terms of grouping learners. Furthermore, according to them, teachers under-assess what learners are capable of, and teachers made assumptions regarding learners' skills. Teachers used group work as a teaching strategy but had assumed that learners already had group work skills. These assumptions reduced the effectiveness of the approaches adopted by teachers and showed a lack of knowledge of

DI in the classroom

Killen (2006) argued that not all learners learn the same content in the same way, whilst Tomlinson and Allan (2000) agreed that there is no single teaching approach that works best for all. A teacher cannot use a *one size fits all* approach in teaching because each learner perceives information in a different way. Moreover, they gain knowledge and create ideas in different ways. According to Stanford (2003, p.84) teachers should "use varied teaching strategies, expanded curricula, and authentic assessment to provide creative and active learning that engages all students (especially those with disabilities) in the construction of their own learning". In particular, it is "the responsibility of schools to adjust to the developmental needs and levels of the children they serve, and schools should not expect children to adapt to a system that does not address their individual needs" (Tomlinson, 2005, p.183). Hence, Tomlinson (2001, p.17) states that "… no practice is truly best practice unless it works for the individual learner".

DI benefits learners with a "very wide range of ability levels, learning styles, and cultural/linguistic backgrounds" (Lawrence-Brown, 2004, p.36). In particular, it provides an avenue through which the teacher can meet the needs of each learner regardless of age, background, prior knowledge, and intellectual or physical ability. However, teachers who view their classrooms as whole entities and who fail to consider the varying levels of readiness amongst learners will either over-challenge or under-challenge their learners. By considering the many differences in prior knowledge and learning styles of learners it is fair to conclude that teachers who do not differentiate in their teaching will reach only a fraction of their learners. In particular, Smit and Humpert (2012) claim that a differentiated classroom has certain characteristics, namely the teacher pays attention to all learners' differences; informal assessment informs learning events; the teacher adapts content, the learning process and the products to accommodate learners' demands; and lastly, the learning process is a joint activity between the teacher and the learners.

Scigliano and Hipsky (2010) claim that DI leads to an improvement in content understanding, inclusion of each learner in the learning process and, coupled with this, learner empowerment, increased self-efficacy and improved academic achievement and success. Tieso (2005) also

found that learners with diverse abilities who were exposed to DI got significantly higher results in mathematics than learners who did not receive such instruction. However, Lawrence-Brown (2004) advocates for teaching to be effective, DI should consist of three qualities, namely:

> "promote active learning, including hands-on experiences, concrete and multi-sensory representations, cooperative learning, and real life applications of concepts/skills; connect subject matter with students' interests, communities, and experiences; and incorporate multiple intelligences and learning styles" (pp.38-29).

In addition, Weinfeld, Barnes-Robinson, Jeweler and Shevitz (2002, p.231) summarise four components as best practices to educate learners with SEN in any setting:

> "gifted and talented instruction in the student's area of strength; opportunities for the instruction of skills and strategies in academic areas which are affected by the student's disability; an appropriately differentiated program, including individualized instructional adaptations and accommodations systematically provided to students; and comprehensive case management to coordinate all aspects of the student's individual educational plan".

Cooperative learning with individualised roles is an effective way to provide DI for gifted learners, but also for learners with SEN (Lawrence-Brown, 2004). Specifically, cooperative learning has the power to enable learners "to learn and work in environments where their individual strengths are recognized and individual needs are addressed" (Sapon-Shevin, Ayres, & Duncan, 2002, p.209). In particular, according to Isak and Tarim (2009), cooperative learning groups offer "mutual academic support" among the learners, "guide them to socialise and help each other" and "increase achievement levels" (p.471). In addition, "group formats offer greater potential for participation, feedback, and interactive construction of meaning" (Emmer & Stough, 2010, p.109). However, DI utilises a combination of teaching strategies of which cooperative learning is only one of them.

Another strategy to be used in DI that benefits all learners in an inclusive classroom is authentic assessment, which focuses on real-life applications of the subject matter (Lawrence-Brown, 2004). Authentic assessment occurs when learners are "expected to perform, produce, or otherwise demonstrate skills that represent real life learning demands in and out of the classroom, without contrived and standardized conditions" (Villa, Thousand, Nevin, & Liston,

2005, p.40). Authentic tasks in mathematics should include tasks such as quizzes, investigations, rubrics and journal entries that allow learners to be creative rather than to repeat memorised procedures.

To ensure maximum attainment, struggling learners should still be provided with additional support, such as assistive technology (manipulatives, visual aids, charts, outlines, picture cues, audio-taped books) and personal assistance (Lawrence-Brown, 2004). Without this additional support, many of these learners will fail. Tomlinson (1999) suggests that teachers, who utilise DI in their teaching, use time flexibly, become partners with their learners and make use of a wide range of instructional strategies. Strategies for learners in need of additional support include emphasis of the important concepts and skills; provision of clear expectations and examples; systematic breakdown of specific strategies, skills, and concepts; specific connections with prior knowledge and experience; and working towards increased independence by fading assistance systematically (Lawrence-Brown, 2004). All these strategies can be incorporated in an inclusive classroom during DI, which could avoid the sense of isolation sometimes experienced by struggling learners.

The main elements of DI in this study should be understood as part of a learning cycle (Smit & Humpert, 2012; Villa, Thousand, Nevin & Liston, 2005; Tomlinson, 1999). Teachers use baseline-assessment as an essential tool to gauge learners' readiness, but also to design teaching activities that are appropriate to all learners, irrespective of their level of performance. Thus, teachers have two main tasks, namely "planning differentiated lessons" and supporting learners "as they are working on individual or group tasks" (Smit & Humpert, 2012, p. 1153). The first element to consider is *attitude*. The constructivist teacher allows the learners with SEN to share the responsibility for their learning, while the teacher pre-assess each learner's knowledge and plan learning events according to his/her specific needs and way of learning. Secondly, the *content* should be taken into account, thus, "what is taught, what we want students to learn, know, and do" (Villa, Thousand, Nevin & Liston, 2005, p.35). Hence the content is the knowledge, skills and values that the learners will acquire about a specific topic. The learning outcomes should be linked with the prior knowledge and learning profile of each learner, and should be elucidated with examples of effective work from other learners. Thirdly, the *process* is

“how students go about making sense of what they are learning”, thus, the way in which the lesson is designed, presented and conveyed to the learners (Villa, Thousand, Nevin & Liston, 2005, p.35). Lessons must be aligned with learning outcomes and learners’ interests, and must be structured to allow learners to work at their own pace. The lessons should offer a variety of teaching and learning strategies. Subsequently, the *product* is “how students demonstrate what is learned”, therefore, the assessment opportunities, where learners are required to demonstrate their competence and what they have learnt (Villa, Thousand, Nevin & Liston, 2005, p.35). A wide-range of assessment forms, - tools and - methods should enable learners to work alone, in pairs or in groups. The learners are encouraged to self-assess their own learning processes, while the teacher diagnoses learning difficulties. DI is interweaved with formative assessment, which is vital for identifying each learner’s following stages of learning and for adapting teaching accordingly (Smit & Humpert, 2012). Lastly, the teacher supports the learning processes by monitoring the learners and providing *feedback* by mentoring learners, suggesting learning strategies and reflecting on the learners’ perceptions of their learning processes.

Both the design of the lesson and the assessment strategies should be based on best practice in teaching and learning that accounts for learner readiness, interests and the learning profiles of each individual learner. When planning lessons, the teacher will take students background information into consideration. At the *content* and *process* stages the design and development of each unique learning activity that will be used in the centre, will be based on Howards Gardner’s model of multiple intelligences (Gardner, 1999), which suggests a learner-centred teaching and an approach that considers the individual differences of learners. In order for the learning centre to be effective, it should meet each learner at their current level of understanding and allow them to move forward along their individual thinking paths to reach their own maximum potential. At the *product* stage learners’ cycle tests and examination results will be used as indicators to show academic performance and level of understanding. Moreover, the teacher will provide *feedback* to the learners throughout the duration of the learning centre to ensure that learners are on track.

By implementing a differentiated teaching learning centre in an inclusive school I can determine the success of the programme in mathematics with a group of learners who differ in terms of their ability level, socio-cultural background, prior learning and learning styles. Also, this study

will contribute to the current pool of research by examining the effects of differentiated teaching at high school level.

2. PURPOSE OF THE STUDY

The purpose of this paper was to examine the use of a differentiated teaching learning centre for grade 8 mathematics learners, so as to determine whether differentiated teaching strategies have an effect on learner achievement and lead to an improvement in understanding of complex mathematical concepts. Therefore, I determined whether the learning centre was successful and whether it facilitated conceptual understanding of complex mathematical concepts through a quantitative technique.

The following research question was addressed in the quantitative approach: *Does differentiated teaching lead to an increase in learner achievement?*

3. DIFFERENTIATED TEACHING IN THE CLASSROOM

Killen (2006) argued that not all learners learn the same content in the same way, whilst Tomlinson and Allan (2000) agreed that there is no single teaching approach that works best for all. A teacher cannot use a *one size fits all* approach in teaching because each learner perceives information in a different way. Moreover, they gain knowledge and create ideas in different ways. Thus, classrooms work best when "students and teachers collaborate to develop multiple avenues to learning" (Koeze, 2007, p.38).

Differentiated teaching provides an avenue through which the teacher can meet the needs of each learner regardless of age, gender, culture, religion, socio-economic status and intellectual or physical ability. Moreover, differentiated teaching shifts the focus of the teacher away from what the child "cannot do" and focuses on discovering new methods that a child "can do" (Laturnus, 2010, p.50). Furthermore, according to Scigliano and Hipsky (2010), differentiating teaching yields multiple benefits for the learners, such as an improved content understanding, inclusion of

each learner in the learning process and, coupled with this, learner empowerment, increased self-efficacy and improved academic achievement and success.

According to Laturnus (2010), differentiated teaching requires an interconnection between new learning and prior learning. Furthermore, learning experiences should relate to real-life situations so they are able to internalise their learning as relevant to their everyday life. Therefore, differentiated teaching forces teachers to move beyond their own preferences to meet the needs of their learners. Specifically, teachers should support those learners who are struggling and assist those who excel, and differentiated teaching encourages teachers to be more creative in their teaching (Laturnus, 2010).

Tomlinson (1999) suggests that teachers who utilise differentiated teaching in their teaching use time flexibly, become partners with their learners and make use of a wide range of teaching strategies. Tomlinson (2001, p.17) states that "… no practice is truly best practice unless it works for the individual learner". By considering the many differences in prior knowledge and learning styles it is fair to conclude that teachers who do not differentiate in their teaching will reach only a fraction of their learners. Koeze (2007) argues that those who view their classrooms as "whole entities" and who fail to consider the varying levels of readiness amongst learners will either over-challenge or under-challenge their learners.

Koeze (2007) argued that the human brain functions by focusing on meaningful information. If learners are confronted with new information that does not match any knowledge that they have previously stored then the brain will regard this information as meaningless and discard it. The brain will always attempt to find an appropriate network which can help them understand and make sense of the new information. Therefore, the teacher should create a lesson, which is exciting, but which also stimulates the necessary neural pathways to enhance learning. Moreover, Koeze (2007) stated that teachers who tier their lessons in such a way that they correlate with the readiness levels of their learners are able to eliminate frustration and boredom in the learning process. Growth in the human brain is facilitated by using co-operative learning strategies and enrichment activities, which relate learning to real-life situations.

Differentiated teaching should be understood as a climate of learning that is created through the use of best practices (Hall, Strangman & Meyer, 2009; Koeze, 2007), and this forms the conceptual framework of this study. Teachers use pre-assessment as an essential tool to gauge learners' readiness. The data yielded from the pre-assessment helps teachers to design activities that are appropriate to all learners, irrespective of their level of performance. Three aspects of the curriculum should be considered as meeting learners' needs, firstly, the *content,* that is the knowledge, skills and values that the learners will acquire about a specific topic; secondly, the *process*, or content is presented and conveyed to the learners, thus the way in which the lesson is designed; thirdly, the *product*, that is the assessment opportunities, where learners are required to demonstrate their competence and what they have learnt.

Both the design of the lesson and the assessment strategies should be based on best practice in teaching and learning that accounts for learner readiness, interests and the learning profiles of each individual learner.

4. RESEARCH METHODOLOGY

The research question is intended to improve educational practice by means of differentiating teaching in a grade 8 mathematics classroom through the use of a learning centre. As noted, differentiating teaching provides each learner with an equal chance for success and the opportunity for effective, optimal learning to take place. The introduction of White Paper 6 on Inclusive Education (Department of Education, 2001), aiming at creating a single education system for all learners, motivated me to conduct research on the implementation of such a differentiated teaching learning centre.

I adopted a pragmatic philosophy that is concerned with "what works" and "what provides solutions" in an authentic situation (Creswell, 2003, p.11). Thus, I used assessment results to find a solution to the problem of meeting a wide range of learning needs in an inclusive classroom. I utilised a quantitative technique.

5. RESEARCH METHODS AND PROCEDURES

5.1 Sample

A convenience sampling technique (Creswell, 2003) was used to select learners from a private, inclusive school in Randburg, South Africa. More specifically, I could only utilise a "natural formed group", namely learners in a classroom setup, which justified convenience sampling (Creswell, 2003, p.162). The school is located in a socio-economically homogenous, middle-class neighbourhood in an urban area, but draws learners from low to high socio-economic backgrounds. The majority were drawn from the surrounding residential areas. Due to the nature of the study, and because it forms part of action research, the school was chosen for the ease of access it afforded me. The intent was to keep the sample within the normal school setting and allow learners to function within a familiar teaching and learning context so as to eliminate extraneous variables.

The learning centre was implemented for grade 8 mathematics learners. The total population of grade 8 learners was 48, divided into two classes of 24. Due to the limited size of the population, and in order to ensure that the findings were valid and reliable, the whole population was selected for use as the sample. The sample of 48 learners comprised 29 girls and 19 boys, the ethnic composition 67% white and 25% black, 2% Asian and 4% coloured. The age of the learners ranged from 12 to 15, with a mean age of 14. Participation was voluntary.

5.2 Data collection

A quantitative design was used by means of analysing assessment results of learners. I used grade 8 mathematics learners' cycle test results from terms 1 and 2 as *pre-test* scores, the teaching for which was not differentiated, but rather where lessons were planned in a *one-size-fits all* manner, to determine learners' current level of achievement in mathematics. Then, the learning centre for grade 8 mathematics learners, which focused on differentiating teaching to meet the individual needs of each learner, was implemented for one week during school time, comprising a total of 250 minutes, before the June examinations. The content used in the learning centre covered all the mathematics curriculum topics taught in terms 1 and 2. Learners could revise and consolidate content knowledge that they had been learning throughout the year

and were able to learn in a way with which they felt comfortable and that matched their individual learning profiles. After being involved in the learning centre they wrote two mathematics examination papers during the June examinations. The first paper covered content from 12 curriculum topics, which had been taught during the first five months of the year, January to May. The second examination paper focused on complex calculations and problem solving questions, with which learners were unfamiliar.

5.3 Data analyses

There are a number of variables that influence and determine learner achievement, such as "future career, language, socio-economic background, interests and achievements in the lower grades" (Spangenberg, 2012). These variables need to be taken into consideration when analysing the results of this study. When the learning centre was implemented, the researcher attempted to eliminate as many extraneous variables as possible to ensure the validity and reliability of the results. There are, however, numerous factors, which are unaccounted for and that may have influenced the results of this study so that they do not accurately reflect the true situation.

The results from the June examinations, as *post-test* scores, were recorded as a group. The results from the terms 1 and 2 cycle tests were compared with the results from the June examination papers, as illustrated in Table 1.

Table 1: Averages of the assessment results before and after instruction was differentiated.

	Before DI			After DI	
Grade 8 classes	Cycle test 1 (Term 1)	Cycle test 2 (Term 2)	Mean average of two cycle tests	June examination (paper I)	June problem solving examination (paper II)
Class 1	72%	71%	71,5%	73%	60%
Class 2	72%	67%	69,5%	70%	60%

Both classes	72%	69%	70.5%	71.5%	60%

The results of the learners' responses to the questionnaire, making used of a 1-5 point Likert scale, were tallied and summarised. Statistical analysis was undertaken to ascertain learners' experiences on whether they thought the learning centre had improved their conceptual understanding of mathematics. Table 2 reports the percentage agreement of learners' perceptions with regard to the use of DI in a learning centre.

Table 2: Percentage agreement of learners' perceptions with regard to the use of DI in a learning centre.

	Strongly disagree	Disagree	Undecided	Agree	Strongly agree	Response Average
1. In the learning centre I was given time to understand new ideas	0% (0)	6.3% (3)	20.8% (10)	41.7% (20)	31.2% (15)	3.98
2. The learning centre helped me to see how Mathematics relates to the real world	0% (0)	22.9% (11)	31.3% (15)	20.8% (10)	25% (12)	3.48
3. In the learning centre I was able to use a lot of interesting materials to learn, not only my textbook	0% (0)	0% (0)	31.3% (15)	43.8% (21)	45.9% (22)	4.35
4. The learning centre helped me to understand problem solving questions	0% (0)	35.4% (17)	33.3% (16)	20.8% (10)	10.4% (5)	3.06

5. The learning centre helped me to understand difficult Mathematical concepts	0% (0)	12.5% (6)	37.5% (18)	31.2% (15)	18.8% (9)	3.56
6. The learning centre helped me to revise for my Mathematics exam	0% (0)	12.5% (6)	39.6 (19)	35.4% (17)	12.5% (6)	3.48
7. The learning centre made me feel more confident in my Mathematical ability	0% (0)	41.7% (20)	33.3% (16)	25% (12)	0% (0)	2.83
8. The learning centre was fun	0% (0)	6.3% (3)	14.6 (7)	45.9% (22)	33.3% (16)	4.06
9. I would like it if we could have the learning centre in class everyday	10.4% (5)	27.1% (13)	25% (12)	14.6 (7)	22.9% (11)	3.13
10. I would like to have the learning centre after school in the afternoons	0% (0)	6.3% (3)	18.8% (9)	50% (24)	25% (12)	3.94
11. The learning centre helped me to remember what we have learnt this year in Mathematics	0% (0)	0% (0)	25% (12)	45.9% (22)	29.2% (14)	4.04
12. I enjoyed being able to choose which	0% (0)	0% (0)	37.5% (18)	33.3% (16)	29.2% (14)	3.92

activity I wanted to do						
13. I liked that I was able to work at my own pace	0% (0)	0% (0)	31.2% (15)	22.9% (11)	45.9% (22)	4.15
14. I would prefer it if I could work with my friend in a group in the learning centre	10.4% (5)	20.8% (10)	37.5% (18)	22.9% (11	8.2% (4)	2.98
Average	10 (1.5%)	92 (13.7%)	190 (28.3%)	218 (32.4%)	162 (24.1%)	3.64
Total respondents						48

The precise means (*X*) and standard deviations (*SD*) pertaining to experiences of the learning centre (dependant variable) by grade 8 mathematics learners (independent variable) (according to the questionnaires constructed for this study) are indicated in Table 3.

Table 3: Descriptive statistics pertaining to experiences of the learning centre by grade 8 mathematics learners.

	Grade 8 mathematics (*N* = 48)	
Survey item	*X*	*SD*
1	3.98	0.887
2	3.48	1.111
3	4.35	0.668
4	3.06	0.998
5	3.56	0.943
6	3.48	0.875
7	2.83	0.808
8	4.06	0.861
9	3.13	1.331

10	3.94	0.836
11	4.04	0.743
12	3.92	0.821
13	4.15	0.875
14	2.98	1.101

N, Total number of learners; *X*, precise means;

SD, Standard deviation

6. ETHICAL CONSIDERATIONS

The ethical committee of the University granted ethical clearance for the study and permission was obtained from the Gauteng DOE, Johannesburg North District and the participating school in Randburg to conduct the research.

7. RELIABILITY

The internal consistency of the data was measured using the Cronbach α coefficient per category of statements on similar constructs, namely Mathematics learning (questions 1, 2, 4, 5), revision (questions 3, 6, 10, 11, 13, 14) and learners' experiences (questions 7, 8, 9, 12). A score of 0.7 and higher was assumed as reliable for this study. The internal consistency of the categories is presented in Table 5.

Table 5: Internal reliability of the categories**.**

Category	Number of items	Cronbach α
Mathematics learning	4	0.955
Revision	6	0.935
Learners' experiences	4	0.926

8. VALIDITY

The questionnaires were shown to colleagues for comments and responses, to ensure that the constructs were clearly conceptualised. Consequently, the questionnaires were amended with regard to timeframes, terminology, readability and clarity. The purpose was to ensure coherency and consistency of the questions. The questionnaires were administered under examination conditions.

The research questions, as outlined in the introduction of the study, were used as a framework for the design and development of the questionnaire and interview questions used in the study. The research questions were broken down into smaller, more appropriate conceptual ideas and these became the concepts to be explored. In this way, the validity of the instrument is ensured because it is testing the conceptual ideas, which form the basis of the study.

9. MAIN FINDINGS

Findings from the analysis of the assessment results

The findings of the study were based on the assumption that if the learning centre had been successful the learners would improve in their results during the June examinations, when compared with their achievement in the mathematics cycle tests from terms 1 and 2. According to the averages of the assessment results before and after DI, the learning centre yielded success for both grade 8 classes as far as knowledge and routine procedures are concerned, as it resulted in a slight average increase of 1.0% in achievement levels in the first paper in the June examination. Of the 48 grade 8 learners who participated in the study, 27 improved their results during the June examination. However, this finding is not conclusive, for the learners did not excel in complex procedures and problem solving skills, with a 10.5% average decrease in achievement level in the second examination paper.

Findings from the questionnaire

The results from the responses to the questionnaires indicate that learners experienced the learning centre to be valuable and beneficial as far as resources concerned. Question 3 (average = 4.35) yielded the highest average on the Likert scale. 45.9% of the learners strongly agreed and 43.8% agreed that the introduction of a learning centre opened up an opportunity for a broad range of new and exciting tools to be used.

Question 13 (average = 4.15) produced the second highest average. 45.9% of the learners strongly agreed and 22.9% agreed that they value being given independence in the learning scenario by working on their own pace.

The two questions rated lowest were question 7 (average = 2.83) and question 14 (average = 2.98). The average response to question 7 reveals that although learners enjoyed the learning centre and found it beneficial it did not improve confidence in their own capabilities. 41.7% of the learners disagreed that the learning centre made them feels more confident in my Mathematical ability.

The average response to question 14 indicates that the statement that learners would prefer to work in a group during the learning centre activity is not so true. 37.5% of the learners neither agree nor disagree that they would prefer it if they could work with my friend in a group in the learning centre. Thus, they would rather prefer to work individually.

Each of the other 10 questions yielded an average score of between 3 and 4 on the Likert scale. These responses show that the majority agreed to some extent with the remainder of the questions on a broad range of issues related to the learning centre (questions 1, 2, 4, 5), namely that it allowed them time to explore new concepts and improved their understanding of complex mathematical concepts and problem solving scenarios. In particular, the learning centre was beneficial in preparing learners for the June examination (questions 6, 10, 11). Lastly, learners experienced the learning centre as enjoyable, which they would like to have in class everyday (questions 8, 9, 12).

10. DISCUSSION AND RECOMMENDATIONS

The results from the quantitative data indicate that differentiated teaching has a positive influence on learner achievement as far as knowledge (level 1) and routine procedures (level 2) are concerned. The differentiated tasks offered in the mathematics learning centre facilitated effective learning before the June examination and lead to a marginal increase in achievement in mathematics. This confirms Rock, Gregg, Ellis and Gable's viewpoint (2008) that "students with disabilities … progress in the general curriculum, and, most important, achieve their educational outcomes" (p.39). However, this study could not find any evidence that differentiated tasks improve complex procedures (level 3) and problem solving skills (level 4). Actually, there was a 10.5% average decrease in achievement in the second examination paper containing these levels. On contradictory, Isak and Tarim (2009) claimed that factors, such as motivation and communication skills could also play a role in achievement in mathematics. Furthermore, the learners' cycle tests and examination results may not provide a true reflection of a learner's ability or understanding with respect to a specific topic as there are many external factors that may influence learner performance. These should be supplemented with other additional assessment tasks. According to Mayer (2002) "when the goal of instruction is to promote transfer, assessment tasks should involve cognitive processes that go beyond recognizing and recalling" (p.232). The study may have been limited by the types of assessment activities that were utilised.

From the responses to the questionnaires it is evident that learners experienced the learning centre helpful in improving conceptual understanding in mathematics. Moreover, they felt that the learning centre assisted them with regard to revision. Most learners agreed to some extent that they would like to have a similar learning centre implemented in the afternoons, after school, as an extra-curricular programme. Furthermore, they experienced the learning centre to be enjoyable. Overall, the quantitative reveasl that the differentiated tasks offered in the learning centre were valuable and demonstrates a possible strategy, which can be used to enhance teaching practices.

A limitation to the study was that the learning centre, offering differentiated teaching, was implemented for a short time, only five school days. Although to a certain extent it was successful and improved learners' conceptual understanding, I recommend that in order to discover the full extent of the success of such a programme, it should be implemented throughout the school year. Furthermore, it should take place after school hours and form part of a voluntary learning programme providing support to all learners with different educational needs in mathematics.

The learning centre was designed to accommodate a wide range of different learning styles. In order for it to be effective it should meet learners at their current level of understanding and allow them to move forward along their individual thinking paths to reach their own maximum potential. Unfortunately, due to time constraints and limited human resources, the differentiated activities did not match the specific learning needs of each learner. I recommend individual pre-assessments to be conducted with each learner before the implementation of the learning centre. Laturnus (2010, p.51) states that in order to adequately meet the need of each individual learner the teacher must use pre-assessment tasks to gain an accurate "picture" of learners' current level of achievement so that teaching may begin at the exact point that learners are currently performing. Furthermore, the teacher should continue to assess the learners throughout the duration of the learning centre to ensure that learners are on track. This is a time-consuming process and will require additional effort and preparation on the part of the teacher, but it will ensure that the learning centre is more effective in achieving the goal of meeting each learner's needs.

11. CONCLUSION

The paper focused on the effect of differentiated teaching as a teaching strategy for grade 8 mathematics learners with special educational needs in a private inclusive school in Gauteng. The aim was to examine the use of a differentiated teaching learning centre for grade 8 mathematics learners, so as to determine whether differentiated teaching strategies have an effect on learner achievement and lead to an improvement in understanding of complex mathematical concepts. It was found that the learning centre yielded success as far as content knowledge is

concerned, but the learners did not excel in problem solving skills. This research study explored a possible avenue for improving educational practice in mathematics. Also, a differentiated teaching learning centre meets the learning needs of a range of learners by accommodating different learning styles. Such a learning centre facilitates and improves conceptual understanding in mathematics and leads to an improvement in academic performance. In support, Tieso (2005) found that learners with diverse abilities who were exposed to differentiated teaching got significantly higher results in mathematics than learners who did not receive such teaching. The research reported in this paper adds to the small body of research in mathematics Education on Inclusive Education in South Africa.

In conclusion, differentiated teaching is a valuable and necessary teaching tool, which helps to meet the needs of an ever-changing, complex and inclusive education system in South Africa. In particular, teachers have a responsibility towards learners to identify their learning preferences and then to capitalise on this. Moreover, teachers have a social and ethical responsibility to ensure that they provide each individual learner with an opportunity to achieve academic success.

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