The implementation of the problem-centered approach in the teaching and learning of mathematics in the junior primary phase in deprived black communities in the Rsa.

Dr. G.F. du Toit

Department of Didactics

University of the Orange Free State

Republic of South Africa

Introduction

People who are literate in Mathematics are absolutely essential for future technological and economical development in the Republic of South Africa. The majority of people who will have to assure that this development will take place in future are currently from deprived black communities. At the end of 1993 only 27,34% of all black pupils in their final school year included Mathematics in their subject package (Strauss, Plekker and Strauss, 1994:12). From these students only 25% passed the final exam in Mathematics. That was a mere 7% of the total black student population in the final school year at the end of 1993 (Edusource, 1994:9). From these statistics it becomes quite clear that something drastically must be done to improve the pass rate in Mathematics and to enlarge the number of black students that present Mathematics as a subject in their final school year. The best place to make a long term investment to address the need of literate people in Mathematics is in the junior primary level (i.e. the first three years in school). This is quite evident from the fact that 36,87% of all black children were in this school phase at the end of 1993 (Strauss, Plekker and Strauss, 1994: 3).

The Research Institute for Educational Planning (RIEP) at the University of the Orange Free State identified this need and found it necessary to get involved at grass roots level. From our research and research all over the world it is evident that the traditional approach in the teaching and learning of Mathematics will not deliver the required mathematical literate people. We decided to focus on the problem-centered approach in the teaching and learning of junior primary Mathematics.

The problem-centered approach

There is a shift worldwide in the last two decades towards the restructuring of the teaching-learning situation in the Mathematics classroom so that problem-solving becomes the basic way of learning Mathematics (Du Toit, 1993b:1-4). The importance of problem-solving was emphasized by George Pòlya who stated (1987:2):

> *We cannot meaningfully discuss teaching, if we do not agree to some extent about the aim of teaching. Let met be specific ... I have an old fashioned idea about its aim: first and foremost, it should teach young people to THINK ... Such "thinking" may be identified with "problem solving".*

Problem-solving is also the way in which Mathematics is learned in the problem-centered approach (Human, 1993:5).

The problem-centered approach is based on three pillars, namely numbersense development, word problems and social interaction.

Numbersense development

The interpretations of numbers as well as the way in which numbers are used in calculations are developed through different levels. It is the task of the teacher to identify the necessary activities, problems and work in writing for each child so that they can develop through the different number levels. These levels in number concept development in short boils down to the following (Human, Murray and Olivier, 1989:3; Du Plooy, H.C.1994:39; Dennis, 1992:3):

Level 1: The ability to count a number of objects correctly in a certain number interval as well as the ability to manage and use the number names and number symbols in that interval correctly. *Counting all* is the calculation strategy.

Level 2: The ability to develop the feeling of how much a number is without constructing that number. In other words it is all about the numerosity of the number. Counting on and accelerating counting (i.e. counting in 2's; 5's; etc.) is the calculation strategy at this level.

Level 3: The ability to interlink a number in a certain number interval to two or more numbers that are easier to use for calculation purposes. Twenty-three for example are seen as 20 and 3 (note, not two tens and three units). The decomposing of numbers, thus the transformation of a number to simpler numbers, is the calculation strategy used at this level.

Level 4: The ability to see, for example, tens as a new unit that is formed from units without losing the actual meaning of the number. The calculation strategy is the standard algorithms, for example the column method of addition (Weimann, 1992:34).

Word problems

The name of this approach, namely the problem-centered approach, clearly indicates that word problems are at the heart of this whole approach. The two most important factors in word problems are the semantic structure of the problem as well as the nature of the problem (Human et al., 1989:2; Nieuwoudt, 1989:271-272). The real world is brought into the classroom by means of word problems and they are solved by the process of problem solving.

The implications for the syllabus are the following (Murray, J.C., Human, P.G. and Olivier, A.I., 1992:6):

- Word problems must be the starting point as well as the carrier of meaning of an operation.
- It must be the source of calculation methods.
- The problems must not be classified as addition -, subtraction -, multiplication - or division problems.
- Word problems must be mixed right from the start.
- Start with the more general cases, for example division with a remainder.
- The contexts must be mixed.

It is important that each child must get the opportunity to explain and to discuss their solving strategies with the other children as well as with their teacher. That emphasize the importance of the last pillar, namely social interaction.

Social interaction

Social interaction, which includes communication, in the junior primary phase is described by Dennis (1992:2) as the ability to verbalize thinking patterns and calculation methods and to debate that meaningfully. To assure that the process of social interaction is successful it must adhere to certain social - and sociomathematical norms. Cobb and Yackel (1994:1) formulate the two types of norms as follows:

Social Norms

Social norms refer to regularities in interaction patterns. Social norms are *realized through expectations and obligations. These include that:*

- *students are expected to develop their own solutions to problems.*
- *students are expected to explain their solution methods to each other.*
- *students are expected to listen to and try to make sense of others' explanations.*
- *students are expected to ask questions and raise challenges when they don't understand or don't agree with someone else's explanation.*
- *students are expected to persist on challenging problems.*
- *students are expected to value meaningful activity over correct answers and persisting on a challenging task over completing a large number of tasks.*

Sociomathematical Norms

Sociomathematical norms refer to normative aspects of mathematical discussions that are specific to the students' mathematical activity. These include normative understandings of:

- *what counts as a **different** solution.*
- *what counts as a **sophisticated** solution.*
- *what counts as a **efficient** solution.*
- *what counts as an acceptable explanation and justification.*

To summarize. In the problem-centered approach the child does not only learn by means of problem-solving, but does he learn to listen to other people, to share and defend his own viewpoint with other pupils and the teacher and does he realize that it is not a sin to make a mistake but it is seen as another learning opportunity. This approach in the teaching and learning of Mathematics is pupil-centered and not teacher-centered. From early on the child learns to take responsibility for his own learning. In other words a total new didactical contract (Murray, J.C., Human, P.G. and Olivier, A.I. 1992:1), i.e. a set of agreements, obligations and expectations between the pupils and the teacher, which includes that pupils may learn from one another through appropriate social interaction, comes into being when the approach in the teaching and learning of Mathematics is problem-centered.

The pilot project

Overview (Du Toit, 1993a:12-16)

In October 1992, the problem-centered approach was implemented as a pilot-project in grade 1 (sub A) classes of 4 schools in the black residential area Mangaung.

In 1993 this approach were implemented into all the grade 1 and grade 2 classes of the four project schools and in 1994 the project was running in all grade 1, grade 2 and std. 1 classes of the 4 project schools. The pilot project in the junior primary phase was terminated at the end of 1994.

Teachers

Fifty two teachers were involved in this pilot project. The teachers attended several inservice training seminars on the problem-centered approach. Various video tapes on this approach, including video's on their own teaching, were shown and discussed with them. The aim was to empower the teachers and one way of doing it was to structure working groups to get teachers actively involved in the planning and the development of worksheets, mathematical games and word problems. A project leader was chosen by the teachers in each school and they were also involved in the in-service training of new teachers to the project. Furthermore three study groups were structured, one for each grade, among the pilot project schools and one of the so called pilot white schools that are teaching Mathematics along these lines since 1990. The results as far as the teachers are concerned are positive. They are dedicated to the task of teaching

Mathematics along these lines. When asked if they would like to return to the traditional way of teaching Mathematics, they replied - Never!

Children

Two thousand three hundred and fifty-six children were involved in this pilot project. This implies an average of approximately forty five pupils per class. Although this approach was only implemented in the fourth quarter of 1992, the results were surprisingly good in the sense that pupils were able to count up to 100 and to do calculations on all four binary operations with numbers up to 80. In the traditional approach they were restricted to the operations adding and subtraction and to the numbers 0-9.

Facilities

One of the four schools does not have electricity. Most of the class-rooms were poorly equipped for teaching Mathematics and none of the school grounds are really developed. Each Grade 1 and Grade 2 class in the project were provided with one big counting frame (120 beads); fifteen small black slates (blackboards) to be used during the carpet sessions; fifty counters for each child; a set of flard-cards for each child; a 100-block for each child and ten sheets of coloured cardboard for each teacher to prepare work cards and mathematical games for group work. The Standard 1 teachers received the same material but were issued with a new set of flard cards (up to 10 000); a 200-block and with 15 pocket calculators per class instead of counting frames.

Community

The results of parents who help their children in Mathematics and who know nothing about the problem-centered approach can be disastrous. The necessary guidelines were set up from research results and were passed on to the teachers who were eager to get the parents involved and to brief them on the do's and the don'ts of this approach.

Research program

The program

Twenty-three grade 1 and thirty-four grade 2 children from one of the project schools participate in the research project and they formed the experimental group. Sixty-five grade 1 and sixty-four grade 2 children from a black school in Kimberley (a city about 180km away from Bloemfontein) were the control group. The task cards as well as the word problems that were used in this research program were set and translated into Tswana, the mother tongue language of most of the children (Du Plooy, 1994:130-135). Some children in the experimental group did attend the Tswana school but their mother tongue language were South-Sotho.

The program for each grade consists of two sections. Section A was aimed at direct calculations where number concept as well as number skills were tested. Section B contained word problems and both these sections contained problems that are in the current syllabus as well as problems that are not in the current syllabus (Du Plooy, 1994:86).

Results

The results were tabulated into two main groups per grade, namely:

* problems within the current syllabus, and
* problems outside the current syllabus (Du Plooy, 1994:86-87).

- *Direct calculations in number intervals within the boundaries of the current syllabus*

TABLE 1:(Only two examples are shown)

Problems (grade 1)	*Experimental Group*	*Control Group*	*Difference*
1 2 + 1	100%	98%	2%
5 4 + 3	95%	46%	49%

Average difference on all five problems: 21.2%

The average difference in the case of sub B's (i.e. grade 2) on the problems that are within the boundaries in the current syllabus was 72,4%. Very interesting was the case of the problem 3 x 9 where 91% of the experimental group did have it correct where to the contrary no one in the control group had it correct.

The results clearly show that the experimental group are performing much better than the control group.

***Table 2:** (Only three examples are shown)*

PROBLEMS (GRADE 2)	*Experimental group*	*Control group*	*Difference*
1 Mapula has 7 red marbles and 6 green marbles. How many marbles does she have ?	100%	92%	8%
4 Mr Katz would like to give the school children some oranges. He buys 6 pockets of oranges, with 21 oranges in each pocket. How many oranges are there altogether ?	77%	0%	77%
5 Divide 30 viennas between 4 children so that everyone has the same amount and nothing is left	85%	0%	85%

Average difference: 45.8%

Word problems within the current syllabus

These results are a clear indication that the pupils in the experimental group are performing much better than the pupils in the control groups and especially on the multiplication and division problems.

An interesting result occurred at the grade 1's. The average difference was -0.8%. The experimental group did have a better score on three of the five problems. None of the experimental group answered the following problem correct while 32% of the control group had it correct.

Godfrey has some marbles. He wins 4 more marbles. Now he has 9 marbles. How many marbles did he have?

Possible reasons for this phenomenon can be language skills, translation of the problems into Tswana, Sotho speaking pupils in the experimental group and help from the teacher in explaining the problem to the control group which was not the case with the experimental group.

Direct calculations on number intervals outside the boundaries of the current syllabus

Both grade 1 (average difference - 65%) and grade 2 (average difference - 59,4%) of the experimental groups performed better than the children in the control groups.

Word problems outside the current syllabus

The grade 1's and the grade 2's of the experimental groups scored on average 24,7% and 71% better respectively than the control groups.

Conclusion

From the results it is clear that the experimental groups are performing better than the control groups. This was also true in the case of bigger number intervals. Interesting is the fact that children from the control groups also managed the bigger intervals which is an indication that children do posses the knowledge to do calculations in these bigger number intervals. It was also clear from the results that the problem-centered approach enable the children to cope with all four operations right from the beginning.

It can be concluded from the results on the word problems that there is an improvement in the language concept and the reading skills of the grade 2 children in the experimental group because they performed much better in comparison to the control group than was the case of the grade 1's.

A comparison of the methods and solution strategies of the experimental groups to that of the control groups show that they (the experimental groups) were more creative and displayed meaningful solution strategies. The self-developed methods of the experimental group were visualized by means of sketches and diagrams while the control group sticked to the methods taught to them. These methods resulted in unrealistic answers with no logic in it.

The experimental groups were much more motivated because they tried and completed all the problems, which was not the case with the control groups. It is evident that the experimental group possessed a good developed number concept as well as better problem-solving abilities which gave them the confidence and the motivation to tackle any problem.

Overview

It is quite clear that the implementation of the problem-centered approach into schools of deprived black communities is successful. Because of this success RIEP was requested to extend the pilot project into the senior primary phase and to implement the problem-centered approach into all "black"-schools in the greater Bloemfontein area in 1995.

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