AN ANALYSIS OF THE USE OF TEACHING AIDS AND THE IMPLICATIONS FOR TEACHING AND LEARNING MATHEMATICS IN QWAQWA PHASE ONE SCHOOLS (SOUTH AFRICA)

Mamokhele Julia Maduna

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ABSTRACT

AN ANALYSIS OF THE USE OF TEACHING AIDS AND THE IMPLICATIONS FOR TEACHING AND LEARNING MATHEMATICS IN QWAQWA PHASE ONE SCHOOLS (SOUTH AFRICA)

Teaching Aids have been a common feature in mathematics classrooms although in some instances they were not appropriately used.

This study was undertaken to explore whether teaching aids have any impact on teaching and learning mathematics, especially in the Foundation Phase classes. It was conducted in two primary schools in QwaQwa, in the Free State Province in South Africa. It was guided by the constructivist approach, which views mathematics learning as the development of ideas, processes and understanding in a social setting rather that the mere passing on of knowledge from teacher to pupil.

Teaching aids, as educational materials, create opportunities which may reveal misconceptions on the part of both teachers and learners. Some teaching aids are quite simple to use and others require training to be able to extract mathematics from them.

The study demonstrated that without strictly classifying them in any preferential groupings, teachers provide varying justifications for using teaching aids in their classrooms. In most cases they incorporate in their mathematics lessons any concrete material that will help pupils to relate mathematics to the real world and provide pupils with hands-on activities that will de-emphasize routine and memorising facts, algorithms, formulas and theorems.

Most importantly the study revealed that teaching aids have a positive effect on teaching mathematics even in less than optimal circumstances, that is, under-resourced, rural, second language classrooms.

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CHAPTER 1

INTRODUCTION

The context

As part of transforming education in post Apartheid South Africa, the National Department of Education launched a new curriculum, CURRICULUM 2005, which adopts an Outcomes-Based Education approach to teaching and learning. The new curriculum advocates a shift from a teacher-centred, chalk-and-talk and stand-to-deliver approach with little opportunity for either learner-talk or learner activity to an approach whose central principle is learner-centeredness (National Department of Education, 1997).

Ottevanger and Benschop (1995) explain learner-centeredness in this way:

a. The starting point is the learner's knowledge, skills, and interest; understanding is derived from the experiences in and out of school;
b. the natural curiosity and eagerness of all young people to learn, to investigate and make sense of a widening world are catered for by challenging and meaningful tasks;
c. teachers empower learners to think and take responsibility not only for their own, but also for one another's learning and total development.

Essentially this new approach to teaching and learning militates against the rigid division between the teacher's and the learners' tasks and responsibilities in the teaching-learning situation. It is seen as a shift from what Brodie (1995, p. 228) calls "traditional transmission pedagogy where both the teacher and pupils believe that only the teacher's knowledge is important" to an approach which creates an environment where meaningful discussions among the children and with the teachers is allowed, and children are

encouraged to share their ideas and to invent and use different strategies for solving mathematical problems.

To facilitate the implementation of the new curriculum, the National Department of Education worked collectively with other role-players to establish projects which would assist subject teachers to integrate this approach in their classrooms. These projects included In-service Education and Training (INSET) activities in the form of workshops, seminars and meetings, and the development of teacher support materials in the form of teacher guides and teaching aids (Beardall, 1995; Ottevanger & Benschop, 1995; Macleod, 1995; Media in Education Trust, 1997).

In her work as an in-service teacher educator in the field of mathematics, the researcher finds that teachers are mainly concerned with improving their learners' learning and improving their own mathematics teaching. Beyond merely advocating constant use of teaching aids, the Department of Education actually provides schools with materials and encourages the teachers to complement these with whatever is available within their environments. The Department also supports television education programmes which themselves advocate the use of a variety of teaching aids. In addition, schools receive offers of products from the teaching aids market. Publishers' and teachers' development projects arrange workshops where teachers undergo training on the development and use of teaching aids. These projects also provide follow up with teachers to try and establish what happens in practice to ensure that the aids are working in the classrooms (Newstead, 1999).

The general assumption is that learning activities that enhance practical work, problem solving, and investigation hinge on the appropriate use of teaching aids which in

turn elicit discussions. There are a number of projects and research findings which justify the use of teaching aids as a vehicle to ensure effective mathematics teaching and learning (Peel, 1993; Sai, 1994; Snyder & Kock, 1999; Cockroft, 1928; Bennie, 1999).

Researchers have discovered that teaching aids enable the teacher and children to engage in solid conversations about something concrete. Having concrete objects to manipulate enables teachers to demonstrate and illustrate mathematical concepts, properties and procedures to create an environment conducive to learning (Szendrei, 1996). When children are given objects to work with and a familiar background they are able to solve problems that teachers never thought they could. Children communicate their thinking to others through verbal explanations and visual demonstration when they are given concrete objects to use. Thus, concrete objects allow children to solve problems without using standard algorithms but through strategies designed and understood by them (Ensor, 1997).

Further research has found that if the tools of real life (scales, clocks, tape measures, containers, etc) or their pictures are used in the classroom they provide evidence that real life applications can become the subject matter of the school mathematics (Szendrei, 1996).

Games are activities that in most cases are played or carried out using concrete objects. Although they take place outside the school, it is important that they be incorporated in mathematics classrooms as well. According to Szendrei (1996) verbal play activities promote the required verbal communication that is important in developing mathematical concepts/vocabulary.

There are, however, authors who caution that teaching aids can be both useful tools and harmful enemies of teaching and learning mathematics (Szendrei, 1996; Groves & Doig, 1999). An example is the use of Cuisenaire rods as a useful tool to assist pupils to understand the concept of measuring as well as the concepts of fractions, Szendrei (1996) says these rods can be harmful when the teachers force pupils to memorise the colour-number associations, such as white = 1. In this case the teaching aid is not used as a tool for communication, reasoning and understanding but an item to depict a meaningless association wherein a number is linked to a colour. This may also cause problems when children have to use other rods, for example, an orange rod as a unit.

Another difficulty associated with the use of teaching aids is the problem of bureaucratic barriers that can kill teachers' enthusiasm. An incident occurred in a school where a grade 4 teacher was supposed to introduce the concept and meaning of a 'kilometre'. To develop insight into spatial relationship and measurement, the teacher wanted to introduce the concept in a practical way. She planned a practical experience where together with her the learners they measured out a kilometre using whatever means they had at their disposal. The learners walked the distance and got a clear idea of how long it was distance-wise. At the same time, they checked how long the activity took on their clocks, and thereby got in some useful practice in telling time. The measurements (time and distance) taken by the learners were to be used to draw graphs. Before commencing the project, the teacher had to seek permission from the head teacher who in turn had to consult with the district manager. The manager objected that allowing the school children to 'roam' the streets during school hours would tarnish the image of the school. This attitude discouraged the teachers from using available teaching aids and

alternative methods of teaching to afford learners the opportunities to manipulate objects, to combine individual work with team work and to encourage self-discipline and voluntary effort.

Another example is a mathematics teacher who wanted to explain the concept of tessellation to a class of 50 students and give them an opportunity to discover which mathematical shapes can tessellate, planned to use the only hall where the learners could, in groups, use different geometric shapes to cover the floor. She was informed that the physical education department had booked the room permanently for the whole semester because they had stored some sports equipment that they needed to carry back and forth to the physical education room. This mathematics teacher was adequately prepared to use the teaching aids available, but poor administration regarding the use of available space was an impediment to her good intentions. Frustrating experiences such as this one, coupled with space availability problems, discourage teachers from using aids (Hawkins, 1981).

Lack of training and orientation of teachers can limit their ability to use teaching aids. Some schools purchase or receive donations of costly teaching aids that are used minimally or never used at all. For example, one school bought Cuisenaire rods which were mainly used to teach fractions. There is no doubt that they are very effective for that purpose and they can also be used for other aspects of maths, including teaching place value. Only one mathematics teacher in that school used them for that purpose. When she left the school, they were packed back in the cupboard to gather dust and mildew. This material was acquired with the good intention of assisting teachers to present better lessons, but attempts were not made to help the teachers to use them. In other situations

where such training is also not provided, the teachers tend to misuse the teaching aids. For example, overhead projectors are often used as chalkboards rather than for their ability to project accurate pictures which will have a positive impact on the lesson. A misuse of teaching aids is a consequence of insufficient training of teachers and low expectations concerning the quality and coherence of classroom teaching.

Heeding arguments for and against the use of teaching aids, this study will endeavour to further investigate the concept of teaching aids as useful tools for improving teaching and learning mathematics.

Author's profile

Mamokhele Maduna, affectionately known as Mami, is a tutor in primary mathematics education and the Director for the Centre for Community Development at the QwaQwa Campus of the University of the North. She received primary education at her hometown, Lindley, in the Free State Province in South Africa. She matriculated at Manthatisi High School in QwaQwa. She received Secondary Teacher Training Certificate and Diploma in Educational Studies (Mathematics Education) at Tshiya Teacher Training College and Leeds University respectively. Uniqwa and the University of Natal awarded her the Degrees of Bachelor of Arts and Bachelor of Education respectively. She is currently registered for the Degree in Master of Arts (Special Individual Programme) with Concordia University and Master of Commerce (Community-Higher Education-Service Partnerships) with the University of Natal.

She has eleven years experience offering primary mathematics education at the colleges of education and university. She has been actively involved in mathematics in-service education and training through independent programmes such as Teacher

Opportunities Programme (TOPS), Promat Colleges and Primary Mathematics Project. She is a member of Association for Mathematics Education in South Africa (AMESA).

Regarding civic responsibility, Mami, is a devoted volunteer. She has initiated and is supporting a number of community development projects focussing on training, self-help and income generation. She is serving on a number of government community development structures such as the Free State Poverty Eradication Strategy, Volunteer South Africa and Eskom Enterprise/Maluti-a-Phofung Municipality Utilities Capacity Building Programme.

CHAPTER 2

LITERATURE REVIEW

TEACHING AIDS

What are teaching aids?

Romiszowski (1968, p.11) postulates that "a teaching aid must, as the name suggests, assist the teaching of a topic. It does not do the whole job. Other methods perform parts of the job and the aid is administered and controlled by the teacher". Teaching aids can be described as constructed objects which represent reality. For students they can facilitate learning. Representing reality in the form of an object to clarify a concept is one way of simply allowing someone to see for herself/himself the characteristics of this object. Instead of using a real watch or wall clock to develop the concept of telling time in a primary class, the teacher can bring reality to class by using cardboard clocks with moveable hands. By means of these constructed objects the teacher offers the learners an opportunity to use reason and make their own deductions while their natural urge to explore and investigate is enhanced.

Szendrei (1996, p. 418) defines teaching and learning aids as (a) concrete materials, meaning real life tools and artefacts, that are "commonly used in out-of-school" settings, (b) artificial material (educational material) mainly conceived and developed for educational purpose, and (c) games including puzzles. She argues that the sort of concrete materials that should be used in mathematics classes depend largely on schools' "educational philosophies as to how the learners learn and what kind of understanding of concepts and processes is necessary" (p. 149).

Schools do not necessarily classify teaching aids into any particular preferential groupings. They accept and use any tool that they hope will change the belief that mathematics is a school subject that can be taught effectively with only a blackboard, chalk, pencil and paper and tables as educational materials. They strive to incorporate in their teaching any concrete material that will help the learners relate mathematics to the real world and provide them with appropriate hands-on activities that will de-emphasize routinization, purely declarative knowledge and memorising facts, theorems, formulas and algorithms (Leonard &Tracy, 1993). In this study, teaching aids are, therefore, defined as any concrete materials, manipulatives, common tools, special educational materials, board games, play activities, pictures and occupational tasks.

Benefits of using teaching-learning aids

We acquire information through our five senses. Researchers argue that there is interdependence between the information that learners gather through the different senses and how they learn and remember it (Van Rooyen & Van der Merwe, 1990; Spencer, 1988). Of all the senses, it has been discovered that hearing and sight are the most used to gather information. For example, a teacher may hold an A4 paper rectangle up to a class. Some of the children may already be familiar with rectangles, they will recognise the object, remember what they learnt and incorporate any new knowledge about rectangles gathered during the lesson into their already existing knowledge of rectangles. This will make the concept rectangle more meaningful to them. On the other hand other children in the class might have no knowledge about rectangles. Apart from recognising that a rectangle is a closed shape and incorporating this into their already existing knowledge of shapes, they need additional experiences through their senses to form a clear concept of a

rectangle. If the teacher gives children an opportunity to hold a rectangle, look at it closely, fold it to discover its properties, match it with similar rectangular objects, the concept becomes meaningful to the children, and it will gradually expand and be remembered when similar situations are presented.

Spencer (1988) and Jacobs (1996) emphasised that one responsibility of the teacher is to organise and present the task to be learned in such a way that learners can assimilate it as efficiently and rapidly as possible. Teachers must therefore put learners into adequate and appropriate sensory contact with the concepts to be learned. Having access to a wide variety of teaching aids will assist individual teachers in finding ways of modifying their instruction to fit the diversified needs of their learners.

Shuard and William (1979) maintain that mathematical ideas will be shaped in a learner's mind according to his or her own activities: touching objects, comparing measurements, reflecting on and communicating the results of the investigations to others. As new knowledge is acquired it becomes part of the learner's mathematical baggage and plays a role in determining the form new concepts will take for the learners.

Shoba (1998), a multi-grade farm schoolteacher, reported that before using teaching aids "teaching maths effectively was a nightmare". He indicated that having teaching aids encourages creativity, curiosity and practical thinking. According to him use of teaching aids also saves time because if a teacher is giving attention to one group (grade) others do not have to wait for her/his availability, but can continue with the investigations.

Vygotsky, cited by Sierpinska (1997) as well as Luthuli (1992) and Nevin (1992) contend that human thoughts are mainly expressed through spoken and written language.

Language provides a vehicle for teachers and learners to engage in discourse about mathematics, to discuss and justify their actions, to record mathematical sentences, and clarify their understanding of mathematics. Mastery of suitable language is therefore essential to assist in acquisition and construction of concepts. Although South Africans speak a variety of different languages, many schools prefer English as the medium of instruction. Luthuli (1992, p. 27) contends that "the richness of English vocabulary can, however, be a source of ambiguity and a burden to the pupils" especially if the medium of instruction is the second language of both learners and teachers.

Besides scaling down or cutting out the use of "technical" language if it "is hindrance rather than help" (Luthuli, 1992 p. 28) researchers recommend that the learners should be engaged in observations and manipulation of materials as they engage in the learning process. The meaning of number concepts should grow out the free exercise of the child's interest and experience with grouping small collections of objects and the working up to larger ones (Szendrei, 1996). This helps to build visual images or create a correspondence between the number name *four*, the symbol *4* and the number of objects it indicates (Nevin, 1992; Szendrei, 1996).

Although children may not have a good range of spoken or written language they are in a position to recognise and differentiate many things, for example, cubes, shapes, fractions (sharing equally), etc. Manipulation of teaching aids such as fraction boards and Cuisenaire rods can help teachers to teach concepts such as notation of an equivalent fraction without having to use technical language. The children's understanding can be demonstrated by shuffling the boards around, or in pictorial form with drawings, even if

at that stage they have not yet acquired the words to denote what they are doing or understand (Shuard & William (1979).

If the teacher makes constant use of teaching aids, not only does this make the lesson more understandable to the learners, but it also contributes to the imprinting of information in the minds of the learners (Mkhatshwa, 1990). Teachers cannot rely exclusively on their voices. Teaching aids are powerful tools to assist the teacher in overcoming the constraints of word-only communication. They help to present a meaningful interpretation of an abstract idea and situation. They complement descriptions and help to explain words, illustrate relationships and give a more accurate impression of the subject matter under discussion. In complementing the spoken word, teaching aids provide a stimulating teaching-learning environment and support the desire to learn and strengthen teaching (Van Rooyen & Van der Merwe, 1996 ; Ellington & Race, 1993).

Consider an example where the teacher needs to explain that "three halves are the same as one and a half or $^{3}/_{2}$ is the same as $1^{1}/_{2}$." The learners' outside classroom knowledge of sharing can be employed. Paper or plastic fraction models can be used to illustrate these facts without having to grapple with the additional level of abstraction imposed by words and numbers. In this example more than two senses will be involved. The learners see, hear and handle the fraction models in order to make sense of words and numbers.

If some of the learners do not have an opportunity to see and handle the models, they may miss the information, and if the teacher is speaking in such a way as to be inaudible, as can happen in large classes, the learners will not hear the aural part of the information.

The use of a variety of teaching aids therefore enriches the learners' learning experience and helps more learners to benefit from the teaching. Because learners differ intellectually and in learning style, they do not benefit equally when only one medium is used. (Van Rooyen & Van der Merwe, 1996). The teacher's task is to help the learners to organise their experiences and learning. This can be done effectively through classroom activities whose purposes according to Coppen (1969) and Romiszowski (1968) could be (a) to develop skills, (b) to present facts, (c) to organise knowledge into concepts, (d) to stimulate imagination and (e) to develop attitudes or change existing ones. The introduction of visually interesting and challenging material into an otherwise routine lesson can become a motivating factor for learners (Schain & Polner, 1966).

If the purpose of the lesson is to help the learners to acquire a manipulative skill to discover that the ratio of the circumference to its diameter is a constant close to $^{22}/_{7}$, the teacher will employ different means such as the spoken word, repeated demonstrations, and practice with and by the learners. She can do demonstration personally in class using circles of different sizes. She can also record all the steps on a video recorder, and alternatively she can illustrate all the stages on a chart where the learners will constantly read the explanation and see steps. She can employ paper-cutting strategies where she will demonstrate and practice with the learners. According to Mkhatswa (1990) the purpose, response and situation will always suggest the means and channels to be used by the teacher and learners.

Selection of teaching aids

Schools that are in more affluent urban communities are often heavily resourced and teachers have many teaching aids from which to choose. However the majority of

schools in South Africa are located within poor rural communities, and many do not even have electricity. Such environments have the potential to put learners at a disadvantage because if the teacher does not investigate the milieu carefully it may seem less rich in teaching aids (Peel, 1993; Lindeque, 1996). Whether the school is within a poor or affluent environment, the teacher has the responsibility of planning for the selection, production, acquisition and use of teaching aids. When selecting teaching aids, the teacher must be guided by the following factors:

The learners and their level of development

Lindeque (1996), Mwamwenda (1994) and Spencer (1988) contend that there is a relationship between the child's stages of development and the process of acquiring, organising, retaining and using knowledge. This means that not all types of teaching aids are appropriate to all levels of learners. It is incumbent on the teacher to select level-appropriate aids. According to Yule and Steyn (1991) and Van Rooyen & Van der Merwe (1996) teaching aids must be suitable for a particular group of learners. Complicated illustrations or models can easily confuse younger children while concrete childish aids may easily bore older ones. Children also have to be able to handle aids. Very small and fragile pieces are not appropriate for young learners. It is not the grade level but the ability of the class that must determine the selection of teaching aids.

Educational objectives to be achieved

Teachers should guard against using any teaching aid just for the sake of using it. Selected teaching aids must serve a definite purpose in the lesson and contribute towards achieving specific objectives. As indicated earlier, no teaching aids teach on their own. The teacher has to plan their use so that the learners can learn from them. It is regrettable

to note that some teaching aids are used to keep the learners busy or entertain them while the teacher is engaged elsewhere. Schain and Polner (1966) urge teachers to ask themselves the following questions before deciding to use a teaching aid:

- Does it help to develop skills in interpreting the concept?
- Does it develop the ability to detect right from wrong?
- Does it help learners to form independent judgements based on facts?
- Does it develop the ability to distinguish fact from opinion?

They further caution about materials that commercial sources offer free in order to sell their products. These must be screened carefully for biases, one-sidedness and hidden messages which are not pertinent to the curriculum.

Relevance of the teaching aids

Central to the teaching and learning of mathematics is the notion that the acquisition of knowledge is a process that takes place in a social setting. Existing knowledge, whether acquired through daily experiences or previous explicit teaching, guides and direct the interpretation and understanding of any new information or setting (Booker, 1998). As indicated earlier, developing mathematical thinking and understanding does not reside in words, activities and manipulation of objects independently; there is a need to provide an environment where the learners' discussions, negotiations and their different ideas and points of views can be reconciled. The school forms an integral part of the community. The teaching aids that are selected for teaching must, as much as possible, be related to the learners' social environment. If teachers bring objects that the learners use in their daily lives into mathematics classrooms or use outside-the-classroom games during mathematics lessons, the result will be a better

contextualised construction of mathematical concepts and a stronger relationship between what children learn the real world.

Another factor that has to be taken into consideration is whether the selected teaching aids will convey the relevant information that the learners have to learn. Teaching aids do not "automatically carry mathematical meaning. They may be concrete but the ideas that students are intended to see are not in the material. [They are] in the way the teacher understands the material and understands his or her actions with it" (Thompson, 1994, p.557). This does not imply that particular aids present any idea unequivocally. While accepting that students can form diverse interpretations of materials, one has to make sure that amongst all correct interpretations formed, the instructional goal stands out clearly or is emphasised by the teacher. This will alert the learners to the fact that one aid can depict and elicit different viewpoints and responses however there might be one that is most appropriate and relevant (Thompson, 1994). The challenge for teachers is to envisage how to abstract mathematical ideas from teaching aids before using them in the classroom.

Nichols and Behr (1982) state as an example that the teacher may ask the learners to bring anything that will show how they use mathematics in their sports, and ask them whether they can describe their sports meaningfully without numbers. This helps to make learning mathematics relevant and meaningful to the learners. With the guidance of the teacher, pupils and parents can help to collect and produce teaching aids.

Negative aspects of using teaching aids

The teaching aids themselves do not possess any particular disadvantages regarding learning. However, it is possible that wrong perceptions about them and their

incorrect use by the teachers may lead to ineffective teaching-learning situations (Van Rooyen & Van der Merwe, 1996). Ideally, each school must have readily accessible teaching aids and sufficient quantities of them. This will not be possible for schools that have limited funds, especially rural schools which cannot generate income from poor families and the sources which support urban schools. To overcome this, teachers must as far as possible avoid commercial teaching aids and improvise or produce their own, but improvisations also need raw materials which also require money.

Most teacher-training institutions do not provide any formal training and practice in the selection and use of teaching aids. Teachers enter schools without this valuable information and when they are faced with reality they end up producing teaching aids that, according to Meyer (1981, p.82) "are technically bad and educationally worthless and this virtually guarantees their demise." To cite a few examples, a teacher shows a slide that contains nothing of value for the pupils, but merely reminds him of what to say next; some teachers write what they want to say on the overhead transparency instead of talking. Learners simply copy down what they see on the screen.

According to Van Rooyen and Van der Merwe (1996, p. 240) "media which contain technical inaccuracies, for example, wrong colouring of biological structures, shape and size of objects or time lapse of events may easily create misconceptions in the learner if the specific learning opportunities are not handled correctly." This is evident in many of the posters that teachers produce and display in the classrooms, where they often illustrate ideas incorrectly. Perhaps this is because posters are sometimes used to decorate the classrooms and not for their educational value.

STATEMENT OF THE PROBLEM

The study intends to investigate the contributions that teaching aids make to the mathematics teaching and learning process, using observed mathematics lessons as case studies.

The study will be guided by these assumptions:

1. The use of teaching aids in mathematics classes elicits discussion between learners and the teacher and between the learners themselves. These discussions provide information about individual students' learning processes;
2. teaching aids facilitate the construction of mathematical concepts and processes;
3. the use of teaching aids improves problem-solving ability;
4. teaching aids facilitate ownership of knowledge and meaning in learners and induce learners to make sense of their ideas and the interpretation of others.

RATIONALE FOR THE STUDY

In South Africa we stand on the threshold of change in Mathematics education. The majority of Foundation Phase (grades R to 3) classes have already made their first steps to embark on implementing Outcomes Based Education whose basic philosophical framework is a constructivist approach. In a constructivist approach mathematics learning is viewed as the development of ideas, processes and understanding in a social setting, rather than the mere passing of knowledge from teachers to learners, often referred to as the empty vessel approach. Existing knowledge, whether acquired through everyday practices or previous learning, is used in the understanding and interpretation of any new information. However, development and construction of meaning does not depend on words, activities and objects in isolation, it requires situations in which learners can

discuss, negotiate, resolve and reflect on their constructions and the mathematical conventions which must be acquired along with them.

My contention is that elementary mathematics basically entails building a match between concrete representations or situations from which mathematical ideas might be drawn and the language that can be established to describe and explain these situations, and ultimately mathematical language whose symbols will be used to convey ideas concisely and meaningfully.

Various studies have been conducted to confirm that inside and outside the classroom, children's activities and games are strong vehicles for creating an environment for sustaining attention, inventiveness and high-level thinking which could enhance children's mathematical activities (Booker, 1998; Adler, 1999).

Most studies have been conducted in school settings where use of concrete materials is the order of the day, the teaching aids exist in abundance, and teachers receive constant assistance and support on how to integrate them in their lessons. In many instances the medium of instruction is the teachers' and learners' mother tongue. These studies have demonstrated the importance of equipping all mathematics classes with sufficient concrete materials. However, few if any studies have been conducted in school settings that are poorly resourced. It would also be helpful to know more about the impact of using concrete materials in classroom settings where the medium of instruction is the second language of both the teacher and learners, and where teachers normally do not receive much external support in terms of resources and refresher courses to update and improve their teaching strategies.

The purpose of this study is thus to describe and interpret the role played by teaching aids in mathematics education. The research questions that the study seeks to answer are the following: How do mathematical teaching aids in less than optimal circumstances, that is, under-resourced grade 3 second language classrooms in South Africa, promote or hinder teaching and learning?

CHAPTER 3

METHODOLOGY

The purpose of this study is to investigate the impact and implications of using teaching aids in mathematics classes in the Foundation Phase of schooling. The most suitable method for the research was deemed to be qualitative investigation in a naturalistic setting. This methodology was chosen for the following reasons:

1. Qualitative research provides a descriptive and interpretive-explanatory account of what happens in a given setting (in this case a natural environment). Researchers strive to know how things got the way they are, what the feeling is of those involved, what they believe in and what meaning they attach to various activities and actions (Gay, 1996; Sekaran, 1984).
2. Researchers conduct the observation of the variables in their natural environment as they naturally occur, not in a researcher-controlled environment under researcher-controlled conditions (Gay, 1996).
3. Preference for this method is also shown by Carr and Kemmis (1986) who, supporting an interpretive approach, assert that the behaviour of individuals consists of actions which can only become intelligible to others by reference to meaning that individual actors attach to them. Observing teachers and learners handling materials and expressing mathematical concepts cannot be interpreted with absolute certainty as the best practice of teaching mathematics, unless one communicates with the individuals to determine whether any learning has indeed taken place. This point is well made in Carr and Kemmis (1986):

> Observing a person's actions (...) does not simply involve taking note of the actor's overt physical movement. It also requires an interpretation by

> the observer of the meaning which the actor gives to the behaviour (...) actions can only be interpreted by reference to the actor's motives and intentions in performing the actions (...) by showing what is going on in a particular situation, by revealing the ways in which the people in that situation make sense of what they are doing, interpretive accounts facilitate dialogue and communication between interested parties (p. 89–91).

By employing an interpretive-account approach, the researcher avoided using a checklist observational design, which usually fails to capture complex interactions within the classroom, especially when confirming the connection between verbal and non-verbal behaviour and the context in which that occurs.

The Free State Department of Education and Culture (FS-DEC) granted permission to conduct research in two Phase One schools from the QwaQwa region in the North Eastern Free State (Appendix A) The researcher also sent written requests to the District Managers and the principals of the participating schools (Appendices B and C). There was no need for the schools to provide written permission because the Provincial Office of the Department of Education acted on their behalf. However, meetings were held with the principals and teachers who were engaged in the study to discuss the rationale, procedures and any concerns that they may have had about the study. Letters were sent to parents requesting consent for their children to participate in the research. These were sent out and collected by the school. Samples are found in (Appendices D and E).

Sample

Schools

To ensure confidentiality all the names appearing in this document are fictitious. The researcher used purposive sampling to select two Foundation Phase schools because

the intention of the study was to acquire in-depth understanding of the use of teaching aids in a particular situation rather than to produce results that can be generalized to a larger population.

The first selection criteria was that teachers must have attended materials development workshops organised by the National Education Department or any INSET providing agency. The researcher had been in touch with these schools through other INSET programmes. The classrooms are equipped with a variety of teaching aids and Lehlohonolo School, one of the two schools selected, has a special room (resource centre) for storage of aids that are not used in the classrooms.

The second selection criterion was the schools must have more than two grade 3 classes. Grade 3 was preferred because it was assumed that learners at this level are well adjusted to classroom practices and procedures. They can distinguish between free-play and educational activities, they have some mathematics vocabulary, they are sufficiently articulate to defend their positions, and they know how to engage in orderly classroom discourse.

Mahlohonolo School is located in a rural village. Parents in rural areas do not usually support school initiatives because of their low socio-economic status and level of literacy. The school is run on a very slim budget. The school has three grade 3 classes.

Lehlohonolo School is located in a town and some of the children come from working-class families. The school can generate some funds from the parents. The school has four grade 3 classes.

Although English is a second language for both teachers and learners, for the past three years the two schools have adopted English as a medium of instruction.

Teachers

They had all participated in teacher development workshops where the researcher was part of the facilitating team. They were therefore willing to welcome her in their classes.

Lehlohonolo School teachers met once a week to review what they had done during the past week and plan for the coming week. Mahlohonolo School teachers met daily after school to review the day's work and plan for the following day. All grade 3 teachers in both schools were females. They had teaching experience varying from 4 to 20 years. Of the seven teachers who participated in the study, none had a Bachelors Degree or a special qualification in mathematics education. Three of them had a three-year Primary Teachers' Diploma and four had a two-year Primary Teachers' Certificate.

Learners

The reason for selecting Foundation Phase learners was that they use teaching aids more frequently than children at other levels. Usage diminishes as they progress to higher grades. The heavier use of teaching aids at lower grades is based on the assumption that children at this level are fresh from the home environment and the school is somehow an unfamiliar territory. Flooding classrooms with teaching aids provides an environment which is more home-like and gives the children the sense of security needed for trying out new ideas and gaining new experiences.

Grade 3 learners (eight to twelve year olds) were preferred because at this stage their thinking has become less egocentric and they are able to respond to others' views. Although most are at the stage of concrete operations (Piaget) they are also capable of making extrapolations from present occurrences or past scenarios. Learners at this stage

have the ability to use acquired concepts to formulate mathematical vocabulary (Schimke, Maertens, & Arnold, 1973). It was assumed that this preference would eliminate an additional variable that could have been presented by the first and second year foundation phase classes.

Table 1
School Profiles

Classes	Girls	Boys	Ages
M1	20	15	9-11 years
M2	16	18	9-11 years
M3	19	18	8-12 years
L1	20	24	9-11 years
L2	25	14	8-11 years
L3	21	24	9-11 years
L4	24	20	8-11 years

The researcher observed 106 learners from three grade 3 classes at Mahlohonolo School and 172 learners from grade 3 classes at Lehlohonolo School. The official entry age into grade R is six years and the ages of the learners who were observed range between 8 and 12 years.

While observing the whole class activities the researcher also kept a close eye on a sub-sample of six learners, three boys and three girls who were suggested by the class teacher. She had asked the teacher to identify two of the children as under achievers, two as high achievers and two as average learners. These children were to be used as key informants, representative of the learners' expression of ideas and feelings, classroom interaction and conceptualisation of mathematics.

Measures

The methods used for data collecting included observations, informal interviews, audiotape recordings and field-notes.

Observations

Gay (1996) observes that observational data can provide better insight into the current status of a particular phenomenon. In this study of the use of teaching aids in the classroom and teachers' and learners' overt actions and reactions, observations afford the researcher an opportunity to view what occurs in the classrooms and get first-hand information from verbal and non-verbal cues. The observer is immersed in the situation and is able to assess it, see for herself/himself which resources are available or not available and observe interaction between the learners, teacher and resources.

Interviews

Teachers

Interview guides (Appendices F and G) served to gather information from teachers before and after class observations respectively. Semi-structured interviews were preferred for this study so as to allow the researcher to hear the teachers and learners freely voice their perceptions, feelings, experiences and understanding without having to be confined to responding to a set of predetermined questions. The purpose of the pre-observation interview was to establish a rapport with the interviewees and gather information on how teachers, individually and cooperatively prepare their lessons. The focus was on how they understand teaching and learning situations and how they contextualize information extracted from different sources, especially teaching aids. These interviews were also intended to lay the foundation for what the researcher could

expect to see in class. Post-observation interviews were intended to lead participants to reflect on what transpired during observed lessons. They were also designed to determine whether teachers took cognisance of the role played by the use of teaching aids regarding lesson development, communication, thought processes, understanding and conceptualisation of mathematical content.

Learners

The researcher used the questions that she picked up while the teachers were presenting and the learners were working, to gather information from the learners' focus group. The purpose was for these learners to explore and share their experiences regarding their expression of ideas, communication, interaction with teaching aids and their understanding of mathematics concepts. Interviews provide an opportunity for the researcher to follow up on inconsistent and unclear responses picked up during the observation lessons. "Reasons for particular responses can also be determined" (Gay, 1996, p.262). Employing multiple data-collecting strategies permits triangulation, a more objective view of collecting data that could not be done when only one method is used.

Audiotape recordings

Audio recordings were used to capture a complete and accurate record of what transpired in the discussions. The researcher tended to leave out important information when taking notes during the interviews. This information was picked up by the tape recorder. Another value of audio recording is that tapes could be replayed many times either for the researcher to review what was said or for others to give their views, impressions and opinions. Audiotapes must, however, be used with caution because they

may distract people who are being interviewed. The researcher must also be experienced in using them and take care that the sound pick up is of good quality.

Field notes

The researcher employed different strategies to collect data at the different stages of the research. For qualitative data, field notes were of prime importance because whether they were taken during the actual research setting (in the class) or recorded soon after leaving the focus groups. These notes described as accurately and comprehensively as possible all pertinent aspects of the situation observed. The researcher included both what he/she observed and his/her personal reactions (Gay, 1996). The researcher also included interpretations and other subjective thoughts and feelings, which, however, were clearly identified and recorded separately from the objective and descriptive field notes.

Procedures

Observations took place during mathematics lessons, which by special arrangement with each school, were conducted on one day. Each class observation took forty-five minutes, that is fifteen minutes longer that the normal teaching period, to allow the researcher to observe and talk to learners without having to take them out of their groups. Initially the researcher had planned to get the six learners to form one group and conduct taped clinical interviews, but from the pilot study it became clear that this created an unfamiliar environment in which the learners became captivated by the tape recorder, and their attention was distracted. As a result, the tape recorder was not used for the learners and special focus groups were not formed.

Establishing a rapport and gaining acceptance in the natural environment of the classrooms was quite easy because the researcher had met all the teachers several times

prior to conducting the research; their schools participated in the Primary Mathematics Project which she had coordinated. When the researcher entered the class, she addressed teachers by their names and seized any opportunity to engage in informal discussion with the learners before the lesson.

In four of the classrooms, her place was usually at the teacher's table at the back of the classroom. In the other two, she sat at the front. The former was a better vantage point because teachers normally stood in front of the class and the learners' attention was easily drawn away from the researcher.

The teachers' lessons were audio-recorded in the entirety. When the learners were working on the activities the researcher would sit with the group that had focus group members. However, these conversations were not taped. Classroom observations were mainly recorded through detailed field notes made on the Observation Protocol Form (Appendix H).

The researcher's observations focussed on the general classroom atmosphere, the resources used, interaction between teachers and learners, and non-verbal communication. Her reactions and comments were written under the Remarks column. They contained a summary of the pre-observation interview with teachers, questions and issues that would be raised with the teachers and with the focus group during the post-observation session. When working with the focus groups, the researcher allowed the discussion to flow without scribbling because that would have distracted the learners' attention. At the end of the day the researcher took some time to complete her notes with additional information that she could remember, and with information from the tapes.

The interviews were conducted during the pre- and post-observation sessions. Interviews permitted triangulation of the data to confirm what had been observed. The interview guides were not followed question by question, but were used to coax the respondents into reacting and saying something. Teacher interviews took the form of round table discussions, where a question would be posed and anyone could respond. Afterwards others either confirmed or contradicted what had been said. Interviews were mainly conducted in English, although here and there Sesotho was used by both the respondents and the interviewer.

The pre-observation interview was intended to provide information about the teachers' past teaching experiences and practices pertaining to the use of teaching aids, especially in mathematics classes. These are situations that the researcher never had an opportunity to observe. Teachers' interviews were tape-recorded and the latter transcribed into discussion summaries, focussing mostly on the gist of the discussion that embraced the variables of interest.

The results of the pre- and post-observation inverviews, and the observations of seven classes of grade 3 mathematics teaching were examined to provide answers for the research question: How do mathematics teaching aids in less then optimal circumstances, that is, under-resourced grade 3 second language classrooms in South Africa promote or hinder teaching and learning?

CHAPTER 4

PRESENTATION OF RESULTS

This chapter includes information about the schools where the data collection took place. It also reports on discussions that took place between the researcher and teachers before and after the observed mathematics lessons. It goes on to provide a narrative and tabular information on concerning the use of teaching aids during the lessons.

GENERAL INFORMATION

Mahlohonolo School

The School

Mahlohonolo School is located in a rural village. Although the parents take interest in their children's education, they are unable to provide financial support to the school because of low socio-economic standards. The school had three grade 3 classes and each teacher taught all the subjects in her class. All grade 3 teachers had received training in the development and use of teaching aids. The teacher-pupil ratio was 1:35 and the mean age of pupils in class was 10 years. The school had a satisfactory collection of teaching aids, which were kept in the classroom cupboards and the school library. The official language of instruction was English.

The Teachers

The teachers of this school met daily after class to review the day's work, plan for the next day and prepare teaching aids. They used work programmes provided by the government as teaching guides. Their other source of information was the textbooks which the school either purchased or had been given by the government. They had

pamphlets which they collected from workshops they had attended and from colleagues in other schools.

The teachers used mathematics worksheets and activity cards which they had developed themselves. These included word problems and special exercises which pupils used when the teacher was busy with other groups. They had pictures, old calendars, 100-grids for both teachers and learners, Dienes blocks and different kinds of counters. They reported that all the teaching aids they were going to use had been used before to teach mathematics and other subjects. The classroom walls were bedecked with colourful posters which the teachers claimed could be used in various lessons. Teachers often exchanged teaching aids.

The teachers indicated that they regarded being observed as an opportunity to know their strengths and weaknesses. Nevertheless, they felt a bit nervous about it, even though they had done previous demonstrations for other teachers and inspectors, and had consistently been praised for their good work.

Teachers expressed a liking for teaching mathematics. This was inspired by workshops that they had attended which introduced them to new ways of teaching English and mathematics. These workshops focused mainly on:

- mathematics content
- grouping children in classrooms and group management
- employing a learner-centred approach
- developing and using teaching aids in different contexts

The teachers reported that some of their colleagues were against the changes, which they perceived to be an extra burden, particularly when the preparation of aids and

the use of the small groups setting within the class were required. Generally speaking however, changes in the school policy and the introduction of Outcomes Based Education was felt to help the teachers work as a team. They used most of the afternoons to share ideas with colleagues and assist one another in preparing lessons and teaching aids.

Although they expressed a liking for teaching mathematics, teachers reported that mathematics and English were difficult subjects to teach and learn. The fact that mathematics was taught in English to second-language children and by second-language teachers was perceived to be a particularly problematic point. The mathematical concepts were difficult enough on their own. With superimposed language problems, teaching and learning were rendered even more difficult. For example, lessons for all three of the observed classes were based on numeration, which teachers referred to as "addition and subtraction". The teachers indicated that although the lessons were focused on mathematics, they would also touch on the areas of language and life skills. They indicated that while such teaching across the curriculum was important, it sometimes took away from their time for teaching mathematics.

Views on Teaching Aids

In general, the teachers believed that teaching aids facilitated teaching, but indicated that in some lessons they could do better without using teaching aids. One teacher reported that teaching aids are not effective if they are not properly chosen and if proper preparation is not done. She maintained that they were useful, and even vital, in cases where pupils did not understand certain concepts. For example, counters would help children to associate or compare the numbers, numerals and the quantities they represented. Telling time is another example. It is not something that pupils can

understand through the spoken word from the teacher only. They learn better if the teacher exposes them to situations where they handle a toy clock, move the hands and relate the position of the different hands with specific times, and also associate toy watches with real clocks and watches at home. Pupils can internalise the knowledge or their understanding of time by continuing to manipulate toy watches with their friends or through incidental reading from clocks at home.

One teacher indicated that she provided pupils with teaching aids with the intention of assisting them in engaging in mathematical discussions while investigating and exploring mathematical concepts, but that the aids had to be used with great care. She pointed out that teachers sometimes lacked the skills and patience to guide the learners through the discussion and exploration processes, even though appropriate teaching aids were being used.

The teacher provided the following example regarding the teaching of the number sentence 35 – 7:

> Pupils are supplied with manipulatives (counters) but they will not be given a chance to explore and communicate their own methods and modes of understanding. The teacher will, in most cases, systematically lead pupils to change 35 counters into groups of 10s and 5 loose counters and then take them through her own processes such as, there are only five ones and you cannot take 7 from 5 ... remember that you have the tens and you can borrow from them ... How many ones have you borrowed ... How many do you want to take away ... Then how many ones and tens are left? ... How do you write it?

She indicated that pupils in this instance tended to use the teaching aids (counters) to answer specific questions or engage in a teacher-directed dialogue. Pupils were concerned with just obtaining "that correct" answer needed by the teacher.

According to the teachers of Mahlohonolo School, if teaching aids are used there is no need for a long series of teacher questions. The pupils can be allowed to manipulate

whatever is in front of them, talk about it, make inferences and come up with strategies and processes that can be used to find solutions to problems. Lessons which are conducted without teaching aids tend to bore pupils, especially the young ones who are used to manipulating objects and exploring with whatever they come across at home.

Lehlohonolo School

The School

Lehlohonolo School is located on the edge of an urban area. The school is mainly populated with the learners from a nearby orphanage and the surrounding poverty-stricken neighbourhood. At the time of the research the school had four grade 3 classes. The teacher-pupil ratio was 1:40 and the mean age of the pupils was 10.5 years. The teachers were satisfied with the teacher-pupil ratio because, according to them, it was stable and better than in other schools. Pupils were arranged in groups in all the classrooms. Each teacher taught all the subjects in her class. The school was sufficiently resourced with teaching aids. It had a special teaching aids room which was set up by a teacher development project. As a result of vandalism teachers could not keep some of the teaching aids in the classrooms. The official medium of teaching was English.

The Teachers

The teachers met once a week to review their work, plan for the next week and prepare the teaching aids. They received teachers' guides and textbooks from the government, neighbouring schoolbook publishers and the school.

The teachers had attended a number of in-service training sessions, which helped them understand and implement classroom management techniques, group work, and new approaches to mathematics content. One teacher reported that she still needed more

such workshops. Others reported that they were no longer attending the workshops because they felt that it was a repetition of what they already knew. As a follow up they would prefer to have "experts" working with them in their classrooms and assisting them in implementing new teaching methods.

The teachers reported that they were nervous about being observed, especially by the researcher, even though two of them had conducted a series of demonstration lessons for teachers from other schools and for inspectors and learning facilitators.

They liked teaching mathematics, although the current changes such as new methods of teaching that were imposed on them without proper orientation and training sometimes discouraged them. They were also threatened by redeployment to other schools because this left them with the burden of additional responsibilities.

Although new developments in the education system were perceived to create some problems, the teachers felt that these changes had encouraged them to improve their teaching, and their relationship with their learners, school management teams and parents. They always tried to relate their teaching to their pupils' life situations, even though the learners were from diverse backgrounds.

As already mentioned, the teachers met weekly as a grade 3 team to review their work and prepare for the coming week. Their meetings focused on the mathematics content to be covered, the integration of other learning areas, available teaching aids and how to use them, and, if necessary, the development or acquisition of other teaching aids. These meetings were very important because the teachers learned from one another. They came to appreciate one another's strengths and weaknesses. The teachers emphasized that

weekly meetings were imperative. There was also constant reference to English and mathematics being difficult subjects to teach.

Their weekly programme was mostly guided by the Departmental Work Programmes, which they had the liberty to modify. They were still using old textbooks as a source of information. It was interesting to note that the teachers regarded themselves as the prime source of information. Their argument was that textbooks, guides, worksheets, occupational tasks and teaching aids were not useful and effective if they were not correctly understood and interpreted by themselves as teachers.

Views on Teaching Aids

The teachers reported that they regularly assessed on the basis of the teaching aids that they had used for previous lessons. The preferred aids for the lessons that were observed included counters, pictures, 100 grids, number cards, chalk slates and occupational tasks.

Teaching aids were felt to help the teachers explain and pupils understand mathematical concepts. For example, some of the learners came to school being able to count up to ten or more, but without being able to write these numbers or interpret what each number meant. Using board games such as "Bush Walk" proved useful because the game board had pictures indicating the number of objects, number words ("one", "two", "three", etc.) and their numeric symbols ("1", "2", "3", etc.). The teachers used this game to build on the counting skills and knowledge that pupils had already acquired. Pupils matched the pictures with symbols and numbers and attached meaning to the words and numbers. They became aware that "4" would always represent any four items, and that 4

is more than 3 and 2 but less than 5 and 6. The game also helped pupils to develop the required numeration vocabulary.

The teachers indicated that misused teaching aids limit teaching and learning and frustrate both teachers and learners. Simply giving the learners teaching aids to manipulate will not guarantee that the learners will acquire mathematical vocabulary and concepts. For example, a child can manipulate paper geometric shapes but he/she needs the guidance of the teacher to understand the mathematics depicted by them, such as their properties and also the vocabulary related to the properties, for example, a triangle has three angles, an isosceles triangle has at least two sides equal. Pupils can only acquire this information through manipulation of aids, exposition and guided questioning by the teacher.

In addition, the teachers reported that using teaching aids can inhibit abstract thinking. Pupils who use counters regularly often find it difficult to understand mathematical algorithms. They continue to use their fingers to solve addition and subtraction problems.

The teachers reported that before they could engage pupils in solving mathematical problems that involved number facts, they used different activities to help them develop "number sense". By this, they meant coming to an understanding of the size of numbers, their order, their patterns, etc. When the teachers started using teaching aids in the form of manipulatives, they realized that even slow learners were able to come up with their own strategies for solving problems because they could make their own interpretation of what they saw in front of them.

Finally, the teachers felt that when teaching aids were present, pupils did not regard the classroom as a strange environment. Real objects, manipulatives, and make believe objects such as money, watches, egg cartons, created an environment where learners felt at home and free to explore.

CLASSROOM OBSERVATIONS

Mahlohonolo School: Lesson 1

The lesson topic was addition and subtraction of numbers. The teacher used English as the medium of teaching, but pupils used Sesotho in group discussions. The teaching aids that were prepared for the lesson were a picture of a family, a picture of a boy with arrows pointing to parts of the body, counters (discs and sticks), blank and numbered (number) cards and occupational tasks (i.e., a pre-prepared task written on a piece of paper and distributed to the children in the classroom).

The picture of the family was displayed on the chalkboard and pupils were asked to say what they saw. The teacher wrote *lelapa* (meaning *family* in Sesotho) and *family* on the board. Pupils focused on finding the subsets of the family which they determined in terms of the relations, gender and age of the family members, for example, father, mother, adults, children, women, men, old people, children, etc.

The teacher asked them to determine the numbers of members in each subset. Some were counting out loud and others silently. They gave responses such as, "three children, one girl, two boys, three females, four males". After some discussions the children noticed that there was a possibility of having five children and four parents because Dad and Mom are the grandparents' children and they are also the three children's parents.

The teacher asked the children to mention the number of members of their own families. Most of the pupils counted on their fingers when mentioning the names of their family members. They mentioned them according to birth order, starting with their parents or with themselves. Some included extended family members. There was a bit of discussion among the pupils about the families who had more members that the others. There was also an agreement struck among themselves that they should not include members who are not living in the same house. They wrote the number of the family members on the board and in their books. They were asked to write the number either in words or symbols. Although they were using Sesotho to communicate, they used English words for the numbers. Others had more than ten members because they had included the extended family members. The teacher asked each pair of students to add up members of their families. Those who had small numbers simply counted on from the total given by the first to find the total numbers of family members. Those who had higher figures to arrive at used fingers after first writing the numbers down.

The teacher then asked each group to add up all the family members of a group. Some groups used the numbers of the individual members, for example,

$$10 + 5 + 9 + 7 + 3 + 4 \text{ or } 8 + 13 + 9 + 2 + 5$$

Others used the form of paired numbers, for example,

$$15 + 16 + 7 \text{ or } 21 + 11 + 5$$

Within the group some members tried to add mentally. When they realized that they were getting different answers, without asking the teacher, they collected and used the counters. They used the following methods:

a. counting three pairs of numbers separately and then counting them altogether, 15 discs and 16 discs and 7 discs, putting each group aside and then recounting them together. Some argued that their initial estimations were close and they repeated the process to confirm.

b. using markings (e.g., 15 = /////////////////), which they crossed out when recounting to check the total. They repeated the chosen process to confirm their results. When groups with the wrong answer were asked why they made a mistake, they reported that they did not have enough time to count and that they did not have counters to help them.

The teachers asked the groups whether they were satisfied with their answers and whether the groups had reached any consensus. They affirmed "Yes" in unison.

A picture of a boy was then displayed on the chalkboard and pupils were asked to mention the parts of the body that they saw, how many there were and how to care for them. Pupils mentioned body parts in either Sesotho or English. They successfully mentioned the parts, their numbers, and how to care for them.

Interestingly, the picture had the boy angled so as to show only one ear. This proved to be a sticking point. Some children insisted that the boy had one ear. The teacher tried to persuade them to say that they could see two ears, but they stuck to their initial claim, which, in a sense, was perfectly correct. To resolve the issue, she ultimately asked them to count one another's ears.

Each group received separate packs of number cards and they were asked to match the pictorial representation with the appropriate number and word (Figure 1).

Pictorial representation	Number	Word
* * * * * * * * * *	10	TEN

Figure 1 Number cards

Pupils were then asked to make their own addition number sentences using their mixed number cards. The teacher demonstrated on the board, asking which cards could be used to show the number sentence *nine boys plus six boys*.

The teacher then gave each group a set of occupational tasks. The task was also written on a chart displayed on the chalkboard. The task read: *Mr Toka's family has a mother, four girls, two boys and a grandmother. The boys are married and have five children. How many members are there in the family?* The teacher explained the exercise thoroughly in Sesotho. Working in pairs, pupils read their own tasks and asked one another procedural types of questions, for example, What do we do? Which number cards do we use? Who will use these cards? Which cards did you take? They then passed the cards around trying to solve the problem. They first used their fingers to add, but then switched to adding mentally. They took quite some time, but got it right.

One pair of pupils drew pictures to represent people and put the relevant number card next to the drawings. When engaged in discussion they did not use their fingers to count, but instead added and subtracted.

The use of teaching aids in this lesson is summarized in Table 2.

Table 2
Mahlohonolo School: Use of Teaching Aids in Lesson 1

Teaching Aid	Uses by teacher	Responses by pupils
Picture of family	• engage pupils in discussions • help pupils recognize and define sets and subsets	• engaged in discussion and negotiated meaning • built sets and subsets of family members; counted family members
Picture of boy	• lead pupils to recognize parts of the body • lead children to count	• named parts of the body • counted parts well except in the case of the boy's ears (see remarks above)
Children's own bodies	• clear up the misconception over the number of ears	• came to agree with the teacher
Number cards	• help pupils compare and understand quantity-numeral-number word associations • help pupils understand the composition and decomposition of numbers	• displayed an understanding of quantity-numeral-number word associations; they matched cards correctly • made different compositions of 15 and could correct quickly as they moved the cards around
Tasks	• engage pupils in discussion of word sums • have pupils relate numerals and number words • develop number facts	• engaged in discussion and interpreted sums • negotiated roles • matched numerals with number words • developed number facts easily
Counters	• given to pupils to aid in addition	• used them for addition and also to check their answers

Mahlohonolo School: Lesson 2

The lesson topic was the addition and subtraction of numbers. The main medium of teaching was English. The teaching aids prepared for the class were a picture of a house with parts made of mathematical shapes, for example, a triangular roof and square windows, a picture of different kinds of houses, counters, number cards, worksheets and occupational tasks.

A picture of a house made of mathematical shapes was displayed on the board and pupils were asked to describe what they saw. In English, they mentioned the mathematical shapes and they named the parts of the house that corresponded to each shape. For example, the roof was a triangle, the chimney - a rectangle, one window - a square, etc. Some of the children went to the board and pointed at the mentioned shapes.

The teacher then asked how many of each shape there was. The numbers were written on the board. The children wrote the number of shapes in both numerals and words. The teacher did not correct misspellings such as fife for five and eit for eight.

Some of the shapes were concealed within others, for example, a square window with four square windowpanes, a rectangular chimney with rectangular smoke. The teacher drew the attention of the learners to these hidden shapes by asking them to identify similar shapes.

Another picture showing different houses – a rondavel, a house with a thatched flat roof, a house with a flat corrugated iron roof, an igloo, a hut, a two-storey house, and a dog kennel – was displayed on the board and pupils were asked to identify the houses that were similar to their homes. Pupils went to the board and pointed them out. One pupil pointed at the dog kennel. The others corrected him saying that he did not live in a

kennel. He indicated that there was such a structure at his home and his dog lived in it. This prompted other children to talk about dog kennels at their homes. Some of them reported that their dog kennels did not look like the one in the picture. At this point the teacher intervened and asked those who had similar dog kennels to raise their hands. She counted them and wrote the number on the chalkboard (9). She then wrote the number of those who had different kennels (10). She put a plus sign between the two numbers and asked how many children had dogs at home. After counting hands, she wrote 24 on the board. She then realized that it was more than the expected total. She repeated the process and got similar results. She asked them whether 10 + 9 kennels is equal to 24. Pupils worked out among themselves. Some added mentally, others used their fingers. They concluded that 19 and 24 were not the same. The teacher then asked why there were19 dog kennels for 24 dogs. After some discussion among themselves, the pupils concluded that five dogs slept outside without benefit of a kennel. The teacher then wrote a mathematical follow-up on the board: pupils who have dog kennels at home = 10 + 9 = 19, pupils who have dogs = 24, pupils who have dogs that do not sleep in dog kennels = 24 - 19 = 5.

Working in their groups pupils identified numbers of each type of housing structure they had at home, for example, rondavels = 6 + flat iron roof houses = 2 + flat thatched roof houses = 6 + dog kennels 3 = X. The children used various processes to try to solve the problem. Some added mentally, some used their fingers, some added pairs of numbers that were easy, made tallies and then counted the tallies. The teacher walked around the groups marking correct answers with a pencil.

Working in their groups pupils were asked to add up the number of houses that each saw in their neighbourhood. Numbers were generated and written down. Then the children worked out totals by adding all numbers mentally until they became doubtful whether the answers were correct, by using their fingers when adding small numbers (one digit), by first adding pairs of numbers that were easy to add and then using counters to add the totals.

A pupil within the group was sitting quietly. When drawn into a discussion by the researcher it was discovered that she could add a series of small numbers mentally, but she relied on a friend or the researcher to confirm her. When adding two digit numbers she relied on the counters and she seemed to be confident that her answers were correct. Though she took some time, she managed to add 20 + 4 + 8 mentally.

A summary of the use of teaching aids in this lesson is given in Table 3.

Mahlohonolo School: Lesson 3

The lesson topic was the addition and subtraction of numbers. The language of instruction was mostly Sesotho. The teaching aids prepared for the lesson included a picture of a boy showing parts of the body, a picture of family, a picture of houses, some number cards and counters.

The teacher displayed the picture of the boy on the chalkboard and asked pupils to mention parts of his body. She asked them to relate the named parts to their own bodies and check how many of each part each person had. Members of a group of six stood at the front. They counted the total number of ears within the group. The first one counted "one, two", the next said "three, four", and so on through to twelve. In the next round

they just mentioned the totals, that is, two, four, six, eight, ten, twelve. Other groups did the same with eyes, feet, hands and fingers.

Table 3
Mahlohonolo School: Use of Teaching Aids in Lesson 2

Teaching Aid	Uses by teacher	Responses by pupils
Picture of a house made of mathematical shapes	• engage pupils in discussions to develop mathematical reasoning • reinforce knowledge of mathematical shapes • lead pupils to count • help pupils to develop addition facts	• engaged in discussions to define mathematics concepts depicted in the pictures • identified mathematical shapes correctly • improved their ability to count • developed addition facts • displayed understanding of addition strategies
Picture of different types of houses	• engage pupils in meaningful dialogue • encourage pupils to share basic addition strategies • reinforcement of counting	• shared ideas, life experiences • became aware of mathematical facts hidden within their environment • developed own number facts • developed and shared strategies to solve addition sums
Counters	• facilitate counting	• worked out addition sums correctly and gained confidence • improved their problem solving ability

When counting fingers, the first pupil counted his fingers up to five. The next pupil counted to five, paused, and then shouted "ten". Yet another pupil counted all her

fingers before confirming that the total was 10. The children then counted in multiples of two (for ears) or five (for fingers), for example, 5 plus 5 is 10 plus 5 is 15 plus 5 equals 20 and so on.

The same picture of a family as the one used in Mahlohonolo School: Lesson 1 displayed on the board. The teacher asked pupils how many people they saw. The children counted them, gave the answer, and confirmed it by going to the board to count the figures in the picture.

In response to the question of what a family was, the children indicated that it was people who are related living together. They mentioned their own families as examples.

The teacher then asked the pupils how many children there were in the picture. After the pupils answered that there were three, the teacher introduced the possibility of there being more (i.e., of seeing parents as the children of grandparents). The children then began on their own to generate number facts based on family relations:

3 females = 1 grandma and 1 ma and 1 girl

4 males = 2 boys plus 1 pa plus 1 grand pa

4 parents = 2 grandparents + 2 parents or pa + ma + grandpa + grandma

Children wrote the numbers corresponding to their own family members on the board and added them, some mentally, others on their fingers, and still others by added pairs of numbers and then totalling. One boy rearranged the numbers in pairs so as to form as many pairs as possible that totalled ten. He explained that he had learnt this method from the teacher. He said he added numbers that make ten first because it was easy to add the zeros. He established these numbers by placing ten fingers on the desk, starting with the first number on the series of numbers to be added, he bent the fingers

that represented that number, and searched for the number that was represented by the fingers that were not bent and paired them off, he then continued with the others until all were paired. He also indicated that he knew some of the numbers that add up to ten by heart. His system was ultimately a good introduction to place value.

Children were asked to write the total numbers of their family members on the blank number cards. They wrote the numeral on one side and the number word on the other. Pupils then named family members as they counted them using their fingers. They then arranged the cards to represent the family members.

The teacher then drew the attention of the pupils to a picture of different houses on the board. Pupils began to talk among themselves about the types of houses they were familiar with. The teacher explained that an igloo was a special hut for Eskimos and that it was made of ice bricks. The teacher pointed to the various types of houses and asked the pupils who had seen such a house to raise their hands. One pupil counted them and wrote the number next to that type of house. The teacher then asked them to add any pair of numbers.

This time the children were faster. At first they used counters, counting out the two numbers and then recounting from one to get the total. The teacher then asked them if there was a faster way. Some finally came up with the idea of grouping the two numbers by 10s and then counting the odd ones. This approach was not immediately assimilated by all of the children; only two pupils were active in the group of six being observed.

The use of teaching aids in this lesson is summarized in Table 4.

Table 4
Mahlohonolo School: Use of Teaching Aids in Lesson 3

Teaching Aid	Uses by teacher	Responses by pupils
Picture of boy's body	• teach pupils parts of their bodies • facilitate discussions on mathematics concepts in the picture	• engaged in discussions • related pictorial representation with reality
Parts of children's bodies, (e.g., eyes, ears, fingers)	• reinforce counting skills • develop number patterns underlying multiplication tables	• counted body parts • developed number patterns as basis for basic addition and multiplication by counting body parts by twos, fives, etc. • added sums correctly • improved their problem solving ability (e.g., started to understand multiples)
Picture of Family	• reinforce counting skills • elicit discussions • link mathematics with other learning areas • develop number facts	• counted family members • engaged in discussions • began to grasp subsets in real life (i.e., parents who are children)
Counters	• facilitate counting	• worked out sums correctly and gained confidence

Lehlohonolo School: Lesson 1

The lesson topic was addition and subtraction of numbers, as in the Mahlohonolo School lesson 1. The teaching aids prepared for the lesson were: 100-grids (board, desk and blank), posters with numerals and number names in Sesotho and English, number cards, Stars and Worms (a Health Education board game), and slates.

Before commencing with the class, the teacher informed the researcher that her pupils were slower than other grade 3 children. She indicated that children might not answer the questions correctly because of the researcher's presence. To break the ice, the researcher asked the learners general questions such as their names, their ages, and their home numbers.

The teacher asked the pupils to count from 1 to 50. Most of them bogged down after 30. They could not pronounce two digit numbers correctly. They then counted up to 20 while was pointing at the numbers. Next, the teacher pointed randomly at numbers and asked pupils to name them. She corrected their pronunciation.

The teacher then asked questions that involved the comparison of numbers, for example, Which number comes before 19? After 19? Between 18 and 20? The teacher used terms such as *above*, *more than*, *larger* and *bigger than* and *less*, *below* and *smaller than.*

The board 100-grid was placed at the level where pupils could reach it. Focusing on numbers greater than 20, the teacher asked questions similar to those posed in the first phase of the lesson. Allowing four pupils to work on the chalkboard at the same time, she asked them to point to any number, name it and write the numeral and number name on the board. They wrote the symbols correctly but misspelled some of the English number names, for example, 18 as *eitin*, 20 as *thwenti* or *twinti*.

She asked them to correct one another but they proved unable to, so she took over the correction duty. She then asked the learners to read numbers from the charts on the walls, and then write down the numbers and numerals from 10 to 20 in their books.

Demonstrating on a big 100-grid the teacher asked the class: "If you are standing on six and walk three more steps, where would you land? Have you increased or decreased the steps?" Pupils counted while pointing at each of the three steps beyond six. The teacher wrote 6 + 3 = 9 and explained that if you walked six steps, and walked another three steps, in all you walked nine steps. She asked more questions of the same nature and used larger numbers.

The teacher then displayed the section of the 100-grid from 20 to 25 and asked pupils to mark these numbers in their grids and answer the following question:

> Motho is living at number 20. He visits his friend who lives in number 25. Did he move backward or forward and how many houses did he pass?

Some pupils said he moved backwards, pointing at the grid (Figure 2); they said he started at the end of the second row and then went backwards to the start of the third row. Others said it is forward because the numbers are becoming big. Consensus was eventually reached that he moved forward.

									20
21	22	23	24	25					

Figure 2 Section of a 100-grid

In response to the second question, some said he passed five houses. They had counted from 20 to 25. Others said that he passed four houses, starting at 20, passing 21, 22, 23 and 24, and then coming to 25. There was no consensus reached in this group until the teacher explained (using a big 100 grid) that it was five houses because he passed 20, 21,

22, 23, 24 and came to 25! She said it must be 5 because 20 + 5 = 25. She asked pupils to recheck what their groups have done and explain to those who did not get 5.

Obviously the teacher wished to demonstrate 20 + 5 = 25, but unfortunately she picked the wrong example (i.e., passing houses) to do so. The result was confusion in the classroom as the children who in fact had the wrong answer were asked to explain the situation to children who had got it right.

The teacher then asked pupils questions based on the previous Health Education lesson. Each group of about 4 pupils received a copy of the Stars and Worms board game. The game board appeared as follows:

25	picture	picture	picture
24	23	22	21
17	18	19	20
16	15	14	13
9	10	11	12
8	7	6	5
1	2	3	4

Figure 3 Stars and Worms board game

Each block on the board described a situation and indicated a consequence, for example,

2 I drink boiled water. Rising Star. Go to 6.
14 My nails are dirty. Swallowed by a worm. Drop to 11.

Pupils played the game while the teacher moved around to explain.

The teacher asked the pupils to write on their slates the number facts based on stars (i.e., rising). The learners spent time explaining messages before noticing the

numbers involved. Once they became aware of the numbers, they developed a series of number facts.

A summary of the use of teaching aids in this lesson is given in Table 5.

Table 5
Lehlohonolo School: Use of Teaching Aids in Lesson 1

Teaching Aid	Uses by teacher	Responses by pupils
Board 100-grids	• teach learners to count • help pupils to compare number names and numerals • help pupils to understand comparison of numbers (more than, less than....) • relate concepts with symbolic representation (increase = + etc) • introduce the concepts of addition	• improved counting • displayed understanding of numbers and numerals • compared sizes of numbers • displayed understanding of addition concepts however word sums used by teachers created confusion
Charts with number names	• introduce incidental reading • help learners to read and write numbers correctly	• showed no awareness of the charts displayed, probably because the teacher did not call attention to them • were not able read and write number names correctly
Board games	• integrate other learning areas (e.g., health education, reading) • encourage reading with understanding • engage learners in discussions (negotiate meaning) • bring fun in mathematics class • develop number facts and number sentences	• practised reading messages and showed understanding of what they read • interacted with each other • developed their own numbers sentences • developed number combinations

Lehlohonolo School: Lesson 2

The lesson topic was place value in addition and subtraction. The medium of instruction was mostly English. The teaching aids prepared for the lesson included 100-grids (board, individual and blank), a 100-grid bag filled with number cards, (this is a cloth bag with 100 pockets, each pocket containing about 10 numbers), number cards (coloured flash cards) and non-permanent coloured marking pens.

Pointing at numbers on the 100-grid, the teacher asked the pupils to count after her up to 30. She covered the numbers from 1 to 20 and asked pupils to count from 21 upwards. When they reached thirty she asked them to count in groups in turn up to 100.

The learners were then asked to explain counting backwards. They said it was counting from big to small numbers, and gave the following examples:

a) {80, 79, 78} consecutively

b) {81, 71, 61} vertically on a 100-grid

c) {81, 72, 63, 54} diagonally on a 100-grid

d) {69, 66, 65, 63, 60} haphazardly

e) {20, 15, 10, 5} by fives.

Using small 100 grids and working in pairs, the pupils first counted numbers aloud and then wrote them on a blank 100-grid. The following sequences were each counted out and then written with a different coloured pen: counting by 2 from 4 to 20, 5 to 25, 26 to 42, and 29 to 49. They then formed number sentences based on the sequences, for example, 6 + 2 = 8, 8 + 2 = 10.

They then marked one target number, for example, 10, and, placing a finger on it, counted backwards the number of spaces indicated in number sentences such as 10 = 8 +

2 (i.e., back 8 spaces and then back 2 spaces). Or they started at the other end and counted up to the target number (10). The teacher asked each pair to work on a sequence of its choice to develop number sentences.

Each group then selected any three pairs of numbers series from 2 to 52, 11 to 41, 14 to 64, 26 to 76, 49 to 99 and 53 to 93, and wrote the numbers in a blank 100 grid. They wrote addition number sentences for each series.

The children then worked on the sequence 18; 27; 36; 45; 54, explaining forward and backward movement. One child picked one set of numbers from the 100 grid pocket and displayed them on the chalkboard and explained the sequence by saying that the numbers were increasing because as one goes down with the numbers of the 100 grid they are becoming bigger. Other children pointed at the 100 grid on the board and explained that between 18 and 27 there are 8 numbers which are bigger than 18. Another pupil explained that after 18 to 27 (excluding 18) he counted 9 more numbers and he knew that they were all bigger that 18. The teacher explained that, if you were standing at 18, you would walk 9 steps to reach 27. Pointing at numbers on the big 100 grid, she demonstrated that 18 plus 9 steps brings one to 27.The pupils worked with their 100 grids while indicating the number of steps that they would take to move either forward or backward. They wrote their findings on the slates. The pupils then repeated some of the previous procedures with different numbers.

. The teacher then used the big 100-grid to explain that by moving forward in the grid they increase the number, for example, 5 steps from 15, lands one on 20, which means 15 + 5 = 20. She then pointed at 20, counted 5 back, and said 20 is 5 more than 15 and 15 is 5 less than 20.

Pupils were then asked to find which number is 10 more than 90, which number is 6 more than 25, and which number is 12 more than 8. They employed different strategies, such as pointing at 90 and moving their fingers directly to 100, covering 90 and counting the 10 blocks from 91 to 100, or just shouting 100 spontaneously. They then worked on two further examples in groups.

A summary of the use of teaching aids in this lesson is given in Table 6.

Table 6
Lehlohonolo School: Use of Teaching Aids in Lesson 2

Teaching Aid	Uses by teacher	Responses by pupils
100 Grids (Board, small, partially completed, blank, number pockets)	• consolidate counting • facilitate construction of mathematics concepts • develop number sense • develop number patterns	• counted accurately when reading numbers from the 100 grid • displayed understanding of combination and de-composition of numbers (4+6 =10 , 10 = 6+4) • developed number patterns, for example, {2;4;6...}, they related this to number sentences 2+2 = 4 ; 4+2 = 6 • compared number patterns to multiplication tables • generalized addition from number patterns to mental additions of sums

Lehlohonolo School: Lesson 3

The lesson topic was developing number concepts and basic number facts. The language of instruction was mostly English. The teaching aids prepared for this lesson included two 100-grid posters, two small grids covered with clear plastic and pasted on

the desks (each pupil had a 100-grid covered with clear plastic),100-grid posters with number patterns coloured, cut-out sections of 100-grids, blank and partially completed cut-out sections of 100-grids, four posters with number names written in English and Sesotho for 1 to 30, 31 to 60, 61 to 70, and 71 to 100, slates, occupational tasks (butterfly number machine), and coloured pens.

Without using any aid the whole class counted from one number specified by the teacher to the other, for example, 21 to 50; 1 to 30; 67 to 80. The children counted in groups. A big 100-grid was then displayed on the chalkboard and pupils went to the board in turn and pointed at the numbers while others were counting. They counted forward and backward, reading numbers from the 100-grid.

The teacher coloured some of the numbers and asked the pupils to write the number names in either English or Sesotho on the chalkboard. She was at first not concerned with misspellings such as *six four* (sixty four); *leven* (eleven); *eit* (eight); *naen* (nine). She later asked the class to identify numbers that were incorrectly spelt, something they had trouble doing.

The teacher displayed a number names chart on the chalkboard, covered the Sesotho names and asked the pupils to read the English ones. The teacher corrected the pronunciation here and there. She then asked pupils to write consecutive numbers in their books. The pupils exchanged books and read what others had written.

The teacher then referred the pupils to the posters displayed on the classroom walls and asked them to use their free time to read the number names aloud in pairs and write them on their slates. She emphasized that they had to be able to pronounce and write them correctly without copying.

Next, working in pairs, pupils completed cut-out sections of 100-grids without referring to a completed copy (Figure 4).

		16	
35			

55		
65		67
75	76	77
85	86	87

Figure 4 100-grid sections

After completing a few more examples, the children started to explain the strategies they used to complete the grids. One boy explained that he knew that 7 must follow a blank next to 5, because in that blank there had to be 6. When asked why all the numbers in one grid column ended in 7, he could not find an explanation. A child who had completed the 5, 15, 25 series answered the question by saying it was a question of range. She pointed out that the numbers increased by 10 each time and then demonstrated on her fingers.

Without referring to a completed grid the children then called out the 6, 16, 26, 36. Using marking pens and small 100-grids covered with clear plastic they counted by two from 2 to 50 and then by four from 50 to 100.

Next, the teacher asked them to cover the numbers from 51 to 100 with a blank sheet and copy the number range that they built when counting in twos on a blank grid (Figure 5).

Some of the pupils copied the first row from a completed grid and then continued by filling in either across rows of the grid or down columns of the grid. Others copied everything from a previously completed grid, while still others simply wrote what their partners called out.

	2		4		6		8		10
	12		14		16		18		20
	22		24		26		28		30
	32		34		36		38		40
	42		44		46		48		50

Figure 5 Half-completed 100-grid

The teacher asked them to name any two numbers that would add up to 20, giving examples 20 = 18 + 2 and 20 = 16 + 4. Reading from the grid, pupils counted 18 blocks and then counted the 2 blocks from 18 to 20. They did the same with 16 and 4. They then wrote all of the other possible number combinations. Some of the learners discovered that a set of numbers can be used twice, starting with either a small or big number, for example,

20 = 14 + 6 20 = 16 + 4

38 = 24 + 14 38 = 14 + 24.

The teacher noticed a group that was counting forward and backwards. For example, for 38 = 24 + 14 they would first pick 24, write it down, put a finger on it, then

count the number of remaining blocks to 38. They would then count backwards from 38, say 14 blocks back to 24, and then write the number of blocks counted and the number that they had landed on. They then gave this as a new combination. The teacher explained to them that they would use the second method when subtracting.

The teacher asked each group to write as many number sentences for 20 and 25 as they could in their books. The researcher spotted two groups that used the method of counting backwards. They said it was easier, because they count once to get two combinations. None of the groups could easily understand this way of proceeding.

Using 100-grid posters, the teacher covered all the numbers from 21 to 100. Using a marking pen, she drew a square around 1, 2, 11 and 12 (Figure 6). She then asked pupils to add 1 + 12 and 2 + 11 (diagonally opposite numbers). Using the counting on method they found that the two sums were the same. She asked them to try using the same method of counting for 2, 3, 12, 13. Finally, the teacher asked pupils to use their own 100 grids, choose any four numbers and add them.

1	2
11	12

Figure 6 Sample 100-grid square

The use of teaching aids in this lesson is summarized in Table 7.

Table 7
Lehlohonolo School: Use of Teaching Aids in Lesson 3

Teaching Aid	Uses by teacher	Responses by pupils
Big Board 100 Grid	• consolidate counting • assist learners to spell number names correctly • develop number sense • lead pupils to understand composition and de-composition of numbers • teach pupils addition and subtraction strategies • allow pupils to develop their own number sentences	• easily counted either way when reading numbers from the 100 grid • practiced and displayed an understanding of number sequences. (e.g., they completed blank 100-grids easily without copying) • completed number sequences easily • compiled different number patterns • invented their own processes doing composition and de-composition of numbers • developed their own number sentences to consolidate/reinforce addition facts.
Charts written number names	• teach pupils to read and write number names • provide incidental reading	• pupils read and copied number names • learners did not use charts except when asked to do so in class • were not able to spell English number names correctly (despite the fact that they were always displayed on the walls)

Lehlohonolo School: Lesson 4

The lesson topic was addition and subtraction of numbers and the language of instruction was mostly Sesotho. The teaching aids prepared for this lesson included

counters, a number line, a laminated big 100-grid, small laminated children's 100-grids, a 100-grid bag filled with number cards, number cards, occupational tasks, coloured marking pens and slates.

A number-line strip and 100-grid were displayed on the board at the level were pupils could reach them. The teacher asked how many girls there were in the class (24) and how many boys (20). Pupils were asked whether there were more boys or girls and gave answers spontaneously. The pupils then counted the number of girls and boys in their groups, and compared groups. They were asked whether there were more girls in the class or the first two groups, and why. They answered that there were more in the class because other girls (mentioning their names) were in the class but not in the two groups. Some simply said that 24 is more than 8. One of the boys counted the girls that did not belong to one of the two groups and said there were 16 of them. The teacher asked the pupils to mark 24 on the number line.

The pupils were then asked to count the number of girls in each group, enter the results in the appropriate place on the number line, and add them up. A certain amount of confusion ensued until the children caught on and successfully reached 24, the total number of girls in the class, using the model in Figure 7 below.

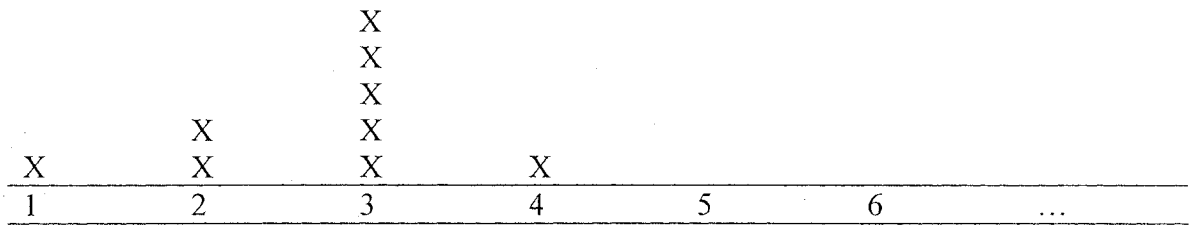

Figure 7 Sample number line

The researcher asked if there was another way of adding to arrive at 24. They demonstrated that they could add the threes and fours, add ones and twos and threes and fours, or add all the threes then twos then fours then ones. The teacher then asked them to show what they had been doing on the chalkboard. One of the pupils pointed to the numbers on the board saying in Sesotho, "1 plus 2 plus 3 plus 4 is 24". The teacher asked the others whether she was right, and they said yes. The teacher asked her to repeat what she had done. She repeated the first process, pointing at the numbers saying 1 plus 2 plus 3 plus 4 is 24. The teacher asked others to help her. One boy pointed at the numbers and said in Sesotho, 1 girl plus 2 girls plus 3 girls plus 4 girls is 24. The teacher remarked that they had left out some girls. Others wanted to try but the teacher pointed at the first row and said you have only counted and added these numbers and forgotten the others, pointing at other rows. She asked one girl to come to the front, then two girls, then three and four and asked the class to count them (10). She matched the numbers of the first row on the number line with the names of the girls. She then continued to match the other numbers with the remaining girls in class. As she was matching the class was counting and adding up to 24.

The teacher erased the numbers for the girls and asked the class to write the boys' numbers. They went on to repeat the complete process for the boys. The teacher again asked the pupils to mark the total number of boys, girls and the whole class with coloured pens on the 100-grid. The pupils were then asked to compare the three numbers {20; 24; 44} and indicated that 44 was larger than 24 and 20, 24 was larger than 20, 20 is smaller than 24 and 44, and that 24 is smaller than 44.

Next, the teacher covered up the 3rd to 10th rows of the grid and asked the pupils to count forward and backward from 1 to 20. They then counted by two, three, four, five, six, seven, eight, nine and ten.

Then, she covered the grid from 11 to 100 and asked them to find any two numbers that added up to 10. One pupil shouted 5 plus 5 and the teacher wrote 5 + 5 = 10 on the board. She asked them to use their own 100-grid and write what they got on their slates. The group that the researcher was working with started with 5 + 5 = 10 and went on to 4 + 6 = 10, 3 + 7 = 10, 2 + 8 = 10, and 1 + 9 = 10.

They arrived at these by pointing at the first number and counting the remaining blocks up to 10. The researcher asked what would happen if they started with the second addend. They followed the same process of pointing at the addend and counting the number of remaining blocks up to 10.

The teacher covered the whole 100-grid and then asked the pupils to put their slates face down and look at her. She took seven counters in one hand and asked how many she would need in the other hand to make them ten. Some of the learners said three spontaneously, while others raised seven fingers and counted the remaining three. The teacher changed hands with the counters, closed her hands and asked how many counters she had in each hand and how many counters she had in both hands. She transferred one counter from the hand with seven to the hand with three, closed her hands, and asked how many counters she had in each hand and how many in both. She repeated this process, moving counters from hand to hand. She questioned the pupils individually. They got correct answers without counting or using aids.

The class then used number cards (Figure 8). Each group was given a stack of ten cards. One pupil showed the front of the card and asked the others for the answer. The pupil who showed the card could see the answer. When they had finished with one stack, they could either go through a second round or take a new stack with different numbers. Some of the pupils in a group could do the numbers mentally. One used fingers to do the sums.

Front Back

Figure 8 Front and back of number cards

Each pupil was given a task with various sums to do. The teacher walked around to check on how they were doing. The pupils used different strategies to work out the sums. Some counted using grids. Some recognized previously seen patterns. Few if any relied on counters. Those who were a bit slower either used their fingers or used mental calculations.

The use of teaching aids in this lesson is summarized in Table 8.

Table 8
Lehlohonolo School: Use of Teaching Aids in Lesson 4

Teaching Aid	Uses by teacher	Responses by pupils
Pupils themselves regarded as sets (class and groups)	• elicit discussions • reinforce counting • interpret classroom situation into mathematical activity • assist pupils in understanding semi-concrete pictorial representation on the number line	• consolidated their counting • engaged in discussions developing mathematical concepts from ordinary classroom situation • understood addition in terms of one-to-one correspondence between numbers on the number line and the girls in the groups
Number line	• compare numbers • elicit discussions • show different compositions of 24 and teach addition	• struggled to understand what the number line represented but finally some of the class sorted it out and were able to generalize
100-Grids	• consolidate counting • development of number concepts • develop number patterns	• improved counting ability and skills • displayed understanding of quantitative comparisons (larger, smaller, etc.) • developed number patterns using different strategies.
Number Cards	• assist pupils to add correctly • consolidate understanding of patterns	• worked out the required sums correctly • sharpened their addition skills (mental addition) • displayed new thinking modes

POST OBSERVATION DISCUSSIONS WITH TEACHERS

At the end of the day the researcher and the teachers had a round table discussion to reflect on the lessons. A summary of these discussions is offered below.

Goals Achieved

The teachers of both schools generally thought that their lessons were successful and that they had achieved some of the objectives they had outlined in pre-observation discussion, including the following:

a. creating an environment for pupils to communicate among themselves and with the teacher about mathematics and other subjects/topics;
b. integrating other learning areas especially language and health education
c. developing number concepts and number patterns;
d. assisting pupils in understanding and developing their own computational skills;
e. leading pupils to use manipulatives for assistance in thinking mathematically;
f. bringing pupils to understand number symbols (numerals) and how much they represent (quantities)
g. consolidating counting skills
h. working on addition and subtraction facts
i. integrating other learning areas such as literacy and life orientation
j. bringing pupils to understand addition in terms of (a) joining sets, (b) counting forwards, (c) joining parts together to form a whole;
k. understanding the shortest way of calculating (algorithms).

The teachers of Mahlohonolo School added that they did not have sufficient time to test for uptake, that is, by giving pupils sums to work out individually.

The teachers went on to discuss the strengths and weaknesses of their lessons. These are summarized in Table 9 below.

Table 9
Strengths and Weaknesses of Lessons as Reported by Teachers

Strengths	Weakness
• Using real life situations to evoke discussions and extract mathematical concepts • Talking about things which can be found in the children's environment • Allowing learners to express themselves in a language that best displayed their knowledge and understanding • Tolerance for error attributable to a lack of knowledge of English (i.e., spelling of words) • Teaching aids which presented the same concepts in different ways were useful (e.g., 100-grids and Stars and Worms game) • Teaching aids allowed for greater learner autonomy and permitting more group work	• Sometimes getting sidetracked by discussions not related to mathematics per se (e.g., discussion of who was included in a family) • Not reserving enough time for learner practice • Losing crucial mathematics time while trying to integrate other learning areas • Running short of reflection time for children because of the use of additional teaching aids

Pertinence of the use of teaching aids

The participating teachers were also led to reflect on their use of teaching aids. Table 10 summarizes the strong and the weak points that they discussed.

On a very positive note, the teachers reported that they felt their teaching of addition had improved over the years. They used to give the pupils sets of rules to follow, a specific and rigid method of adding, and a list of sums copied from the textbooks. The only teaching aids used were counters, usually sticks and stones. They said that now they

were using a lot of teaching aids in one lesson and this compelled them to change the patterns of communication in their classroom. They had moved from a one-way teacher to pupil pattern to a three-way, teacher-to-pupil, pupils-to-teacher and pupil-to-pupil pattern. The new directions of communication allowed learners to express their informal strategies and understand that mathematics questions do not have one and only one answer, which comes from the teacher.

Table 10
Strengths and Weaknesses of the Use of Teaching Aids as Reported by Teachers

Strengths	Weakness
• Colourful pictures and other aids were appealing to the learners and captured their attention. • Number cards created important links between numerals and words. They could also be rearranged with ease. Furthermore, the children could get in good practice by creating their own. • Counters allowed children to consolidate knowledge. • Aids gave the children access to new thinking modes (e.g., counters opened the way for mental adding and subtracting; they also helped the children find novel solutions). • 100-grids could help children see mathematical patterns. • The children's response to aids showed not only their degree of understanding of concepts, but the extent to which they understood how to work with the aid. Thus the aids allowed teachers to learn more about their learners.	• The aids could occasionally distort reality and cause the children difficulty (e.g., the boy with one ear showing and the 100-grid that led the learners to say they were going backwards to get to a higher number). • Sometimes aids were used when the task could have been done more quickly or at a higher intellectual level without them (e.g., the use of counters). • At times too many aids were used and teachers were unable to find time to wrap up lessons. • Aids had to be used properly and given adequate attention to be useful (e.g., 100-grids had hung on classroom walls in full view of the children for years before the teachers started using them and calling learners' attention to them).

Chapter 5

DISCUSSION

This study investigated the contributions made by the use of teaching aids in the teaching and learning of mathematics in primary schools. Unlike previous studies, most of which have been conducted in highly resourced schools, this study looked at poorly resourced schools with limited teaching aids. The discussion of the findings in this chapter will derive its structure from the research hypotheses that underlie the study. Each of the four hypotheses will be addressed in turn.

Hypothesis 1

> *The use of teaching aids in mathematics classes elicits discussion between the learners and the teachers and between the learners themselves. These discussions provide information about individual students' learning process.*

In this study all the teaching aids were effectively used to engage both the teachers and learners as active participants in the discussions. They created an opportunity for the teachers and learners to either talk or listen to each other. The discussions that resulted from the use of the various aids allowed the learners to articulate their own thought processes and share their thinking with others. For example, while working with the picture of the family, the pupils explained the formation of subsets and discussed family membership. The learners used the various tasks they were given as opportunities to negotiate strategies and procedures. These findings are similar to those reported by Koen (2000).

It is important to note that the discussions which resulted from the use of the aids could not always be predicted by the teacher. The rather lengthy discussion that resulted from the picture of the boy that showed only one of his ears is a case in point. The teacher

was obviously taken aback by some of the pupils' insistence that the boy had only one ear, and being caught by surprise, she had trouble reacting to the situation. There was obviously a clash between the very concrete thinking of some of the pupils and the more highly abstract thinking of the teacher. Without the use of the picture and the ensuing discussion, the difference between the teacher's thinking and the children's thinking might not have come to light.

In any discussion of classroom exchanges in South African schools, the question of language must be addressed. All the teachers and learners participating in this study switched back and forth between Sesotho and English during the lessons that were observed. Only one of the seven lessons was conducted almost entirely in Sesotho. As Luthuli (1992) points out, the use of a second language to explain mathematics could have been a source of ambiguity and thereby a burden to the teachers and learners. This study revealed that the teachers avoided confusion by scaling down and, in some instances, cutting out the use of English so that pupils could communicate freely in Sesotho. Indeed, the teachers proved to be masterful at moving the pupils between languages while preserving comprehension. They were extremely careful to prevent English from becoming a barrier to mathematical comprehension.

The teachers readily took advantage of both pictures and objects to reduce the cognitive burden of the children. For instance, they used number cards so that the children would not have to spend a lot of precious class time writing out numbers, and they used pictures to facilitate the introduction of new English vocabulary.

The pupils' lack of English was not the only linguistic problem to be overcome in the classes. Sometimes the children's L1, Sesotho, also got in the way of mathematical

thinking and the learners had trouble saying what they meant in any language. Here the teachers allowed the children to use their fingers, number cards, counters, or whatever means they could find to express what they had understood. Without the use of teaching aids, the children would have been unable to articulate their understanding.

Hypothesis 2

Teaching aids facilitate the construction of mathematical concepts and processes.

Mathematical concepts do not just emerge automatically in a classroom situation. They are constructed out of the children's experiences in dealing with different aspects of their environment. This study witnessed teachers exposing pupils to a variety of experiences by providing a wide range of teaching aids that they could either view or manipulate. For example, learners were encouraged to use their fingers to discover the number patterns of 10. Once these patterns had been acquired, the children were able to go on to an understanding of place value. In some of the classes (M1, M3 and L4), pupils moved from using fingers and counters to passing around and rearranging number cards to display their knowledge of basic addition and mathematical operations (e.g., commutative law). The use of the different aids clearly allowed the children to move from very concrete to more abstract thinking about addition.

The board game that the children of Lehlohonolo School played in the first lesson observed there helped them acquire mathematics concepts. When playing the game, the pupils worked on their reading and started to make important links between written instructions and mathematical operations. For example, the pupils read rising-star instructions and then understood they were supposed to add; and read swallowed-by-a-

worm instructions and understood they had to subtract. They then went on to perform mental addition and subtraction operations as they played the game.

In many respects this activity addressed the concern expressed by the teachers prior to the observation period that integrating different learning areas in one lesson would lead to a loss of important mathematical concepts. Clearly the children were able to use mathematics across the curriculum in well-controlled situations such as the board game.

In contrast, the number name charts that were displayed on the walls did not prove to be successful teaching aids. This is likely because the charts had been in the same places for years without the pupils' attention being called to them during lessons. In the end, the charts were perceived to be more decorative than useful by the pupils. This shows that the mere presence of teaching aids is not enough. The learners must be brought to pay attention to aids if they are to be useful to the learning process.

All teachers were aware that in teaching numeration there were essential concepts that needed to be developed. In every lesson there was an attempt to improve pupils' understanding of counting as basic strategy for solving addition and subtraction facts. The teachers used a variety of teaching aids to engage pupils in counting activities. Reinforcement of counting process was not done in isolation but was coupled with the development of processes, such as identifying number patterns and cultivating number sense.

It is interesting to note that the teachers in all observed classes used children's body parts either to introduce new knowledge or to reinforce the existing concepts. The use of children's body parts ranged from simple counting on fingers, thus making pupils

physically aware of basic mathematical facts, to the construction of complex mathematical processes, such as developing multiplication tables. In a sense, the children's body parts are an ideal teaching aid; they are always readily available for use and they have a direct sensorial connection to each child.

Hypothesis 3

The use of teaching aids improves problem-solving ability.

It is evident from the study that the use of teaching aids allowed the pupils to consolidate existing problem-solving strategies and invent new ones. For example, the learners used their 100-grids to decompose numbers and then saw that they could use the grids to solve addition problems posed by the teacher. They then went on to create new number facts of their own by using the grids to count backwards as well as forwards.

Unfortunately for the pupils, some of them proved too astute at problem-solving for their teachers to keep pace. On some occasions one or two pupils in a class found quick and easy solutions to addition or subtraction problems by means of their 100-grids. When the teacher failed to understand how they had found their solutions or when the solution was not the one the teacher had in mind, the learners were told not to use the new way they had found and were forced back to old ways that the teachers could comprehend and control. While such situations were made possible by the use of teaching aids – in this instance the 100-grids – they could hardly be interpreted as a downside of teaching aids. The fact that the children were able to find innovative solutions is very encouraging. The problem in these instances lies with the teachers who failed to keep pace with the children's thinking, and not with the instruments that allowed the children to think better and faster. Rather ironically, some of the teachers who were unwittingly

outstripped by their learners had claimed in pre-observation interviews that it is not proper to make learners dependent on strategies that yield answers that satisfy teachers.

This study has revealed that teachers and pupils alike were able to improvise on the spot by turning unexpected responses and events into mathematical problems with the help of teaching aids. For instance, one team of pupils drew additional pictures of family members to be able to show quantity-numeral associations more clearly, and one of the teachers turned a dog-kennel mismatch into a lesson in subtraction.

Teachers are usually eager to lead their students to use strategies that they claim to be efficient. This study has shown, however, that better learner uptake might result when pupils are allowed to use the strategies they understand best, that is, those which they develop on their own. When working with numbers cards and 100-grids the pupils in the observed classes used a variety of different methods to complete the tasks they were assigned. Because they were working with common materials, it was easy for the learners to share their different strategies with classmates and the teacher. This sharing resulted in substantial learning as some pupils abandoned poor strategies that they had developed and adopted more successful strategies discovered by other pupils. This exchange of knowledge was short-circuited every time teachers intervened to impose their own strategies on the group.

Hypothesis 4

> *Teaching aids facilitate ownership of knowledge and meaning in learners and induce learners to make sense of their ideas and the interpretation of others.*

The results of this study support Booker's (1998) contention that providing a real context for pupils to view and manipulate teaching aids, and to verbalise their actions, thoughts and interpretations, helps in the construction of mathematical ideas. For example, during

the fourth lesson at Lehlohonolo School pupils demonstrated an ability to work at an advanced level of abstraction after starting from the familiar situation of counting pupils in the class. After seeing girls standing in small groups at the front of the room, the pupils were eventually able to grasp the far more abstract representation offered by a number line.

However, it should be pointed out that the teachers' follow up activities were not always sequenced to allow for easy learner progression to higher levels of abstraction or better thinking modes. For example, when the 100-grid was used to solve the passing in front of houses problem in the first lesson observed in Lehlohonolo School, it created complete confusion because the starting point (the 20 box) was poorly chosen. Had the teacher added a step to the sequence and asked the children to use their grids starting from 21 or 22 and staying on the same line, the children would have been able to make the leap from adding on fingers to using the 100-grid far more easily.

To facilitate ownership of knowledge and meaning, an environment has to be created in which previous knowledge can be consolidated and new knowledge can be accessed rapidly. Mathematics has a hierarchical structure and it is incumbent upon teachers to plan their learners' activities well, including which aids to introduce, when to introduce them, and how to render them comprehensible.

In classes in which a number of different teaching aids were used, the focus sometimes shifted away from the acquisition and consolidation of knowledge to getting through all of the aids to be included in the lesson plan as quickly as possible. For example, the first lesson taught in Lehlohonolo School included 100-grids, charts with number names and a board game. The pace tended to be rushed and the children were not

given sufficient time for reflection. The second lesson in the same school relied only on the 100-grids and the children had far more time for discovery. One suggestion to primary mathematics teachers might be to reduce the number of teaching aids used in one lesson so that time is allowed to follow up on pupils' ideas and properly wind up a particular line of thinking.

This study has, to a certain extent, revealed that mathematics classes in which teaching aids are used differ significantly from traditional classes where the teacher is the sole custodian of knowledge. In the observed classes, pupils were able to investigate a variety of personally conceived strategies rather that simply copy the teacher's or the textbook's. Pictorial representations assisted pupils in reflecting on their own outside classroom experiences and applying their knowledge to their reality. For example in the second lesson at Mahlohonolo school, the picture of a house was first seen by pupils as just a familiar object for discussion but later used by them as a springboard to stimulate imagination and make sense of concepts such as mathematical shapes and numbers.

Although the study was not intended to make any comparison between the classes, it was interesting to note that there were some noteworthy similarities and differences regarding the use of teaching aids in the seven classes. The range of variety of teaching aids used in one class differs from one to five. The classes that used the least number of teaching aids (L2 and L3) proved to be more focussed than those that used more aids. Furthermore, communication in classes that relied on fewer aids was well organised and followed a sequential line of thinking. Activities were followed through and wrapped up to form a coherent whole. On the other hand, the classes that used a wide

variety of teaching aids (M1 and L4) were characterised by discussion that focused more on the tool rather than on the assimilation of mathematical concepts.

Another interesting observation is that teachers in classes M1 and L4 displayed lack of confidence in their learners' ability to understand concepts, use different thinking modes, and acquire new mathematical strategies and new language to talk about their knowledge. The teacher of class M1 reported to the researcher that her class was the slowest of all. The teacher of class L4 did not attempt to use English when teaching. Not surprisingly, the learners in these two classes appeared to live down to the low expectations.

Chapter 6

CONCLUSIONS

Achievements of the Study

This study was designed to investigate the impact of using teaching aids in selected grade 3 mathematics classes. It has revealed that the participating schools attached significant importance to having teaching aids available for use in the classrooms. The schools made special places available for the storage of teaching aids and provided opportunities for teachers to acquire both teaching aids and knowledge to use them effectively in the classrooms.

Furthermore, it was evident from the results of this study that teaching aids are being used in a useful way to teach mathematics in the participating classes. All the teachers had recourse to teaching aids and all the learners profited in some way from their use. This said, the study has also revealed that not all the teaching and learning that went on with the use of the aids was optimal. Some aids proved better than others and some uses of aids proved more effective than others.

The differences in the use of aids between teachers, and problems encountered by individual teachers revealed that further training in the use of teaching aids is essential. This could be provided at the pre-service level for teaching students and in in-service form for teachers already in the work force.

The pupils observed during the study were familiar with most of the teaching aids used and took good advantage of many of them. In rare instances the aids got in the way of learning, but the fault lay more with the way the aids were used than with the aids themselves. Once again, further teacher training in the use of aids is recommended.

Another important conclusion of the study is that almost without exception the pupils and teachers enjoyed using the aids. Thanks to the aids the pupils dealt with mathematics tasks with greater confidence and enthusiasm. Furthermore, they understood the importance of taking the responsibility for the whole process rather than simply completing given calculations just to satisfy the teachers. The use of teaching aids ultimately brought the attention of the pupils and the teacher to bear on mathematical processes rather than on mere results.

Given the interactions that occurred between pupils and between pupils and their teacher thanks to the use of teaching aids in the classroom, it is safe to conclude that mathematics teaching is not the domain of the teacher only and that mathematics learning can clearly be enhanced when aids lead learners to handle objects and make conjectures, build arguments, justify answers, and negotiate meaning.

Curriculum 2005 advocates a shift from a chalk-and-talk approach with little opportunity for either learner-talk or learner-activity to a more learner-centred approach. This study has successfully demonstrated that one of the routes to learner-centredness is to make teaching aids available in the classrooms for use by both the teachers and pupils.

Limitations of the Study

This study was conducted in a total of seven classes in two different schools and data was collected from one lesson per class. This means that the sampling size was very small and that the findings cannot be generalized to a larger population.

Another limitation of the study is the fact that it was not longitudinal. Each class was observed once rather than being followed over a period of time. In an optimal

research situation, observations would have been done regularly over a period of several months.

Although the teachers who participated in the study were not strangers to being observed, it is highly probable that their performance in the classroom during the observed lessons was influenced by the presence of the researcher. The teachers knew that the researcher was interested in the use of teaching aids. This knowledge may well have led them to rely more heavily on aids than they might have in the course of an unobserved lesson. This said, it was clear from the reaction of the children in the classes that teaching aids were a regular part of their daily lessons. The children knew what to do with almost all of the aids and did not appear surprised to see them.

Another observed limitation was the small number of data-gathering instruments used. The researcher relied mostly on the field notes to record classroom observations. When she was working with the focus groups she missed out on the interactions between the teachers and other learners. Use of a video recorder would have been useful to capture information about the whole class and also validate what the researcher had picked up from the focus groups. However, introducing a video camera would have disrupted classroom routine and resulted in chaos. Audio recordings of discussions between the learners themselves and between the learners and teachers would have been less disruptive and would have given a better picture of their interactions than field notes, but making audio-recordings in crowded classrooms with horrific acoustics is very difficult. The background noise in all of the classrooms was such that it would have been impossible to make out individual voices on the tape most of the time.

In spite of these limitations, the study was a worthwhile exercise for researcher and teachers alike. It has provided unique insight into what teaching aids are present and how they are being used in under-resourced South African schools with a 100% Black clientele.

Recommendations

This study has permitted the identification of a number of research problems and questions that should be addressed in the future. For instance, the findings arrived at in Chapter 5 of this research are based on the study of grade 3 classes in the Foundation Phase of education. It would be useful to look at how teaching aids are being used to teach mathematics at both higher and lower grade levels where learners are likely to react quite differently to materials.

This study was conducted in schools with very limited resources. It would be interesting to look at classrooms with different levels of resources to determine what sort of relationship exists between the number of aids available and the use made of them.

In this study it was initially assumed that the teachers would be able to select and use teaching aids in the classrooms in an optimal manner. However, the findings suggest that teachers' ability to extract mathematical ideas out of ordinary objects and situations is far from being either equal or optimal. Research in the direction of training teachers to acquire skill in using teaching aids would add to existing knowledge in the field of pre- and in- service teacher training and education.

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APPENDIX A

FREE STATE PROVINCIAL GOVERNMENT

Education

Private Bag X20565 - Bloemfontein - 9300 - South Africa
55 Elizabeth Street - CR Swart Building - Bloemfontein
Tel.:- +27 (0) 51 - 4074911 - Fax : +27 (0) 51 - 4074036

Enquiries : Mr W.B. van Rooyen/LB
Reference no. 0-1/11/3/3

Tel. : 051-405 5504
Fax : 051-403 3421

02 August 1999

Mr T. I. Makume
Director (South Africa): Uniqiwa / Concordia Project
University of the North
Qwa Qwa Campus
Private Bag X 13
PHUTHADITJHABA
9866

Dear Mr Makume

REQUEST TO CONDUCT RESEARCH IN THE FREE STATE DEPARTMENT OF EDUCATION

1. Your request dated 9 June 1999 and the detailed research requests for eleven students received on 1 July 1999 refer.
2. Research titles applied for:

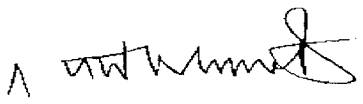
Name:	Titles:
Me Makgoarai Mofutsanyana:	The effect of intervention strategies used by teachers on the academic performance of learners with behaviour and/or emotional disorders in the Eastern Free State.
Mr Letekatoa Taoana:	Conceptual difficulties experienced by grade 12 pupils in basic concepts of chemistry, specifically the Mole.
Mr Molefi Tbobileng:	A survey of what facilitates or hinders ESL learning in QwaQwa high schools.
Ms Maria Nkosi:	How effectively do pre-primary school playroom(s) assist children to develop holistically (i.e., Intellectually, Emotionally (affective), Socially and Physically (fine and gross motor) through various learning centers (areas)
Mr Molefi Mofokeng:	Rethinking the sources of disaffection among secondary school students.

Mr Tatolo Edgar Molebatsi:	An investigation into the high failure rate of ESL grade 12 Exams.
Mr Thabo Letho:	An effective student - Teaching practice programme.
Mr Mohapi Mohaladi:	The relationship between matric pass rate and the extent of Total Quality Management (TQM) principles implemented in Harrismith District Schools.
Mr Paseka Maboya:	A study of parental / guardian involvement in decision making structures and processes at tertiary-level institutions in South Africa with special reference to tertiary educational institutions in the Free State Province.
Ms Varaluxmi Chettv	The role of organisation and management towards increasing pupil achievement in rural schools.
Me Mamokhele Julia Mami Maduna	Supporting curriculum change in the classroom: An analysis of the impact of the use of teaching aids in mathematics teaching and learning in QwaQwa primary schools.

3. Permission is granted for the above students to conduct research in the Free State Department of Education under the following conditions:
   - 3.1 The names of teachers/learners (where applicable) must be provided by the principals.
   - 3.2 Officials / Principals / HOD's / Teachers / Learners (where applicable) participate voluntarily in the projects.
   - 3.3 Where applicable, the names of schools and respondents involved remain confidential in all respects.
   - 3.4 Completion of questionnaires by teaching staff and learners must take place outside normal tuition time of the school.
   - 3.5 This letter must be shown to all participating persons.
   - 3.6 Individual reports on the 11 projects must be donated to the Free State Department of Education after completion of the projects where it will be accessed in the Education Library, Bloemfontein.
   - 3.7 You must address a letter to the Head: Education, for attention
     W.B. van Rooyen
     Room 1211
     C.R. Swart Building
     Private Bag X20565
     BLOEMFONTEIN
     9301
     accepting the conditions as laid down.

4. We wish the students every success with their research.

Yours sincerely



HEAD: EDUCATION

APPENDIX B

The District Manager
Harrismith District
Free State Department of Education
Private Bag X827
WITSIESHOEK
9866

Dear Mr Manese;

PERMISSION TO CONDUCT EDUCATIONAL RESEARCH IN YOUR SCHOOLS

I humbly request permission to conduct an educational study at *two primary schools* in your district. The purpose of this study is to establish the impact of the use of teaching aids in mathematics classroom. I will conduct interviews with teachers and observe mathematics lessons. If permission is granted, I will work with two grade 3 teachers and their learners in each school. The study is planned to take place for about two months commencing from August to October 1999.

I am studying for Masters Degree (Mathematics Education) with Concordia University, Montreal, Canada. I am also offering a course on Educational Media Production at UNIQWA where I am also involved in mathematics education teacher in-service programmes.

Participating teachers have received some training on development and use of teaching aids.

There are no foreseeable risks to the teachers and the learners who will be participating in the study. The school and parents have the right to withdraw any pupil(s) and teacher(s) at any stage of the study.

If you need further clarification regarding the study I will be happy to do so in a meeting or by telephone, (058) 713 0211 w/ (058) 623 0068 h.

Yours sincerely,

Mamokhele Mami Maduna (Ms)

P. O. Box 1346
HARRISMITH
9866

APPENDIX C

The Principal

Dear Madam;

PERMISSION TO CONDUCT A STUDY AT YOUR SCHOOL

1. I humbly request permission to conduct an educational study at your school. The purpose of the study is to examine the use of aids in teaching mathematics in your school. For this purpose I propose to observe two grade 3 mathematics classes and to interview the teachers and the learners in the classes. I also request an interview with you.

2. This study should take approximately two months from August to October 1999. I shall conduct the research personally. I am studying for a Masters Degree with Concordia University, Montreal, Canada. I am also offering a course in Teaching Media Production at UNIQWA. I am also involved in Community Outreach programmes and mathematics education INSET programmes.

3. The Harrismith District Manager has granted permission to consult your school.

4. There are no foreseeable risks to teachers and learners who will be participating in the study. School authorities and parents have the right to exclude their children from this study. All the information gathered will be kept confidential

5. I should appreciate your extending my request to the School Governing Board and teachers for approval.

6. If you have any questions regarding the study I will be happy to clarify them at a meeting or by telephone, (058) 713 0211 (W) or (058) 623 0068 (H)

Yours sincerely,

Mamokhele Mami Maduna (Ms)
P. O. Box 1346
HARRISMITH
9866

APPENDIX D

Mr&Mrs/ Mr/ Mrs/ Ms.....

Dear Parent

CONSENT FOR YOUR CHILD TO PARTICIPATE IN A RESEARCH PROJECT

The principal and staff of.....have approved my request to conduct a study at their school. The purpose of this research is to observe the use of teaching aids in teaching mathematics in two grade 3 classes.

Your child will participate in the study by way of:

* being observed to see how he/she participates during mathematics lessons
* being interviewed about his/her mathematics learning

There are no foreseeable risks to the participating learners. Parents are at liberty to withdraw their children from this study. All information regarding the school and learners will be kept strictly confidential. The report will not make any reference to any individual participant.

I therefore humbly request that you permit your child to participate in this study. Your consent is absolutely voluntary. Kindly complete the attached form and send it back to school.

For further information regarding this study, please contact the school principal or myself at (058) 713 0211(W) or at (058) 623 0068 (H).

Yours sincerely,

M.J. MADUNA (Ms)
P. O. Box 1346
HARRISMITH
9866

APPENDIX E

PARENT/GUARDIAN CONSENT FORM

AN ANALYSIS OF THE USE OF TEACHING AIDS AND THEIR IMPLICATIONS FOR TEACHING AND LEARNING MATHEMATICS IN QWAQWA PHASE ONE SCHOOL (SOUTH AFRICA)

I ..... (Full name of parent Guardian) hereby

GRANT CONSENT for my child .....

who is attending school at .....

to participate in the in the study to be continued by Ms M. Maduna.

Parent/Guardian:

Signature :.....Place :.....Date :.....

I DO NOT WISH my child .....

who is attending school at .....

to participate in Ms Maduna's study.

Parent/Guardian:

Signature :..... Place :..... Date :.....

APPENDIX F

PRE-OBSERVATION INFORMATION

School: ..... Date: .....

Teacher: ..... Class: .....

The main purpose of the preliminary interview is to establish a rapport with teachers. To arrange for the lesson observation and to establish types of teaching aids they have and will be using for the observation lesson and to allay any fears regarding the observation.

1. Do you like teaching mathematics? Why?
2. Do you think mathematics teaching has changed over the years
3. Have you been to in-service course recently? How did they help you?
4. How and when do you prepare your lessons?
5. Which topic are you going to teach for the observation? How did you choose it?
6. What are you hoping to achieve with the lesson?
7. Which main specific concepts do you want the learners to acquire and understand?
8. What is your main source of information for this lesson?
9. Which teaching aids are you going to use?
    i. Have you used them before?
    ii. Where are the teaching aids stored?
10. Generally how do you think teaching aids facilitates or hampers teaching?
11. How do you feel about being observed?

Adapted from the Primary Mathematics Project, President's Education Initiative, University of Western Cape Research

APPENDIX G

POST OBSERVATION QUESTIONNAIRE FOR TEACHERS

School ..... Date.....
Teacher ..... Class .....

1. Which mathematics concepts and processes were you hoping the learners would acquire?
2. Do you think this lesson was successful in addressing these?
3. In what way do you think the teaching aids facilitated aids that you used facilitated the lesson in terms of:
   i. patterns of communication amongst the learners and between the learners and the teacher?
   ii. process that the learners go through in understanding mathematics concepts?
   iii. process that the learners go through in completing mathematics tasks?
   iv. working with the learners who found the tasks either too easy or difficult to understand?

APPENDIX H

LESSON OBSERVATION PROTOCOL

School :..... Teacher:..... Date :..... Class :..... Size :.....

Time	Teacher Actions	Pupil Actions	Resources	Comments & Questions

Adapted from Primary Mathematics Project, President's Education Initiative, University of Western Cape Research.