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FINAL REPORT: SHORT VERSION

THE PRIMARY MATHEMATICS RESEARCH PROJECT 2004 - 2007

Towards evidence-based educational development in South Africa

Eric Schollar
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Malamulele North East and East Circuits		**Malamulele Central Circuit**	
Boxahuku	Matiyani	Shigalo	Shimambani
Gonani	Manghena	George Hasani	Khanani
Magomani	Mahlohlwani	Titirheleni	Tiyiselani
Maphophe	Botsoleni	Ripindzi	Mavuyisi
Hisekelani	Tivoneleni	Xihlovu	Xibangwa
Khodobi	Govhu	Makhapule	Mdanisi
Ngomunghomu	Mashobye	Mavambe	Mahonisi
Makahlule	Nkandziyi	Mapapile	Langutani
Hangalakani	Nxanguyintswha	Magangeni	Mutshena
Nyavani	Makhasa	Magoda	Tivanani

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ABSTRACT

The fundamental motivation of the Primary Mathematics Teacher Project was the enduring persistence of poor outcomes in mathematics education in South African schools despite the post-1994 dispensation, including the introduction of the new Outcomes Based Education curriculum in 1998, and the ever-increasing allocation of significant national resources to the education system.

National and international comparative data has conclusively demonstrated that the vast majority of South African learners are performing well below the minimum expected competence levels for their respective grades, a reality ultimately manifesting itself in the dismal performance of our learners at matriculation level, especially in terms of higher grade passes; only 1.5% of the 1995 Grade One cohort survived to achieve HG passes in the 2006 matriculation examinations.

However, the problem of relatively poor or even declining national performance in mathematics is not unique to South Africa as the Trends in Mathematics and Science Study (TIMSS) has made clear. Alarm has been raised in many countries, chiefly those in the West; the United States and Australia being the most recent examples. Much of the recent research and policy literature flowing from these countries has one thing in common, an increasing focus on the nature of the curriculum, the learning theory upon which it is based and the teaching practices that it encourages. In short, constructivism is under increasing pressure to provide empirically reliable evidence that it is an effective theoretical basis for a national curriculum, and especially for the teaching of the fundamentals of mathematics to young learners in primary schools.

In South Africa, also, evaluations of many different relatively small scale interventions since 1994, operated chiefly through NGO organizations with funding from the private sector and independent development trusts, have recently been re-scrutinized in an effort to distil their findings about what is going on in mathematics education in this country. In the great majority of these studies, the achievement by interventions of changes in those teaching practices encouraged by constructivist approaches does not result in correspondingly significant improvements in learner performance levels.

Phase I of the PMRP was initiated in 2004 with the intention of applying an empirical approach to an investigation of the nature of the outcomes of mathematics education in our primary schools. The key data sources used during Phase I consisted firstly of the completed scripts of 7 028 learners from 154 schools in 24 districts in all 9 provinces; the second consisted of the original rough workings used by 4 256 of these learners in the course of completing the test. The scripts were drawn from the evaluations of 6 different studies of intervention projects conducted between 1998 and 2004. This data set was supported by the data set of interviews and lesson observations conducted during the same studies.

Phase I concluded that the fundamental cause of poor learner performance across our education system was a failure to extend the ability of learners from counting to true calculating in their primary schooling. All more complex mathematics depends, in the first instance, on an instinctive understanding of place value within the base-10 number system, combined with an ability to readily perform basic calculations and see numeric relationships. This problem is caused by the application of ineffective learning theories in classrooms, chief amongst which is the virtual disappearance of memorization, consistent drill and regular extensive practice of learned content. Learners are not being given the opportunity to develop the neural pathways and structures required for the development of higher order cognitive competencies in mathematics. Closely associated with this causative factor has been the virtual abolition of the concept of a national or provincial syllabus of study combined with textbooks designed to give effect to this syllabus; in favour of the belief that

teachers would be able to develop their own learning programmes, using a variety of materials, against a curriculum consisting of broad outcomes, and somewhat more specific assessment standards. The consequence has been that quality of outcome has varied wildly from school to school as the completeness and complexity of content to which learners are exposed came to depend on individual teachers. National and provincial assessment policies and practices have failed to produce a 'fit' between what learners are supposed to know, and what they do know, at each grade level and, as a consequence, the vast majority of our classes have become, in effect, multi grade classes in which teachers are faced with learners with every conceivable level of ability from the innumerate to the genuinely competent.

Phase II of the PMRP consisted of the development of a set of teacher and learner materials based on the findings of Phase I over 2006, followed by their field testing over 14 weeks in a sample of 40 Limpopo schools over 2007. After the end of the field test, the materials were adapted to take account of its findings.

The programme materials are based on a number of key design feature derived from the research conducted for Phase I, they:

- are concerned with Learning Outcome One only – Numbers, Operations and Relationships
- are based on experimentation with a structured 'teacher-centred' approach to the learning and teaching of mathematics involving an emphasis on direct instruction by teachers, and the use of memorization, mental arithmetic, drill and extensive regular applied practice for learners, before extensions into more complex activities (like games and puzzles, etc.) are attempted.
- attempt to provide a programme embodying a grade-differentiated capacity allowing for teaching in classrooms where learners have widely differing levels of subject competence.
- provide a diagnostic and formative assessment system to control the exposure of learners to the correct complexity level in practice of learned content.
- provide teachers and learners with a complete syllabus of study, backed by a complete set of materials, based on the Assessment Standards of the National Curriculum Statement.

The research design predicted that the intervention programme would result in both:

- A significant increase (i.e. over +2%) in score of the project group over the control group between pre-and post-testing.
- A significant difference in the frequency of calculation methods, as against counting methods, in the project over the control group by the end of the programme.

The study provided strong and reliable empirical evidence that the approach embodied in the PMRP materials results in rapid and significant improvements in learner performance in Learning Outcome One. The report presents a mass of impact data that can be summarized in the overall greater degree of increase of score over baseline of the project group when compared to the control group. When the data is based on all of the schools irrespective of the degree of exposure of learners to the compete programme (the range of coverage was from 3 to 14 weeks), the figures are:

- Grade 4 +50%
- Grade 6 +64%

When the data is controlled for a more reasonable coverage of at least 11 weeks of the programme (80% coverage) the comparable figures are:

- Grade 4 +83%
- Grade 6 +102%

Recent work by Nick Taylor suggests that statistically significant impacts are usually measured in only around half of the schools in most intervention projects. The figures obtained during the PMRP from schools uncontrolled for programme coverage are:

- Grade 4 90%
- Grade 6 94%

When the data is controlled for at least 7 weeks of the programme (50% of coverage), all 100% of the schools that achieved this level of coverage (80% of the schools) recorded significant impact, none less than +5.5%.

That all of these impact figures were achieved over 14 weeks is very significant indeed – the clear implication is that it need not take years to improve primary level mathematics if an effective approach is employed in doing so. Finally, it is self evident that a short programme such as this costs very much less than the 3 or more years typical of most intervention programmes in primary level mathematics.

SUMMARY OF FINAL REPORT

The origins of the Primary Mathematics Research Project (PMRP) lie in an extended period of research in South African education since the watershed year of 1994. This research, consequently, has taken place within the context of the transformation of the national education system that is intended to increase access to schooling, eradicate the inequitable and dysfunctional effects of the past and provide the basis for a sustained period of individual and economic development. Central to the achievement of the long-term strategic objectives of educational transformation are questions of quality of outcome, especially in relation to mathematics and science.

It is clear that the country needs to improve the supply of skills for which the prerequisite is numeracy and mathematics. It is equally clear that the development of these skills is based, in the first instance, on the national school system. However, while the state has achieved a greatly increased level of access to schooling, the quality of the outcomes of both the primary and secondary systems remains an issue of great national concern.

Until recently, the only national measure of the outcomes of the school system has been the matriculation examinations; the class of 2006 was particularly interesting in that it was the first 'post-Apartheid' cohort of learners that has passed through the school system since 1994. A total of **1 676 273** learners were enrolled in Grade 1 in 1995 - these learners were in Grade 4 in 1998, the year that Outcomes Based Education was introduced in the form of C2005.

- 528 525 learners (31,5%) survived to write the matric exams in 2006
- 330 513 learners (19,7%) wrote the mathematics exam
- 25 217 learners (1,5%) achieved a pass at Higher Grade in mathematics

We now also have reliable data on the performance of South African learners at other levels of the education system through the National Systemic Evaluation (NSE) of the National Department of Education, and through three international comparative studies in which we have participated.

- Trends in Mathematics and Science Study (TIMSS)
- Southern and Eastern African Consortium for Monitoring Educational Quality (SACMEQ)
- Monitoring Learner Achievement Study (MLA)

Both cycles of the NSE have demonstrated that the majority of children are performing poorly. In the Grade 6 cycle (2005), learner performance was graded on a scale of achievement in terms of the assessment standards of the National Curriculum Statement (NCS) – over 80% of all learners are performing well below expected minimum levels in mathematics. All three of the international comparative studies demonstrated that the majority of South African children are achieving performance levels well below those of their counterparts in both Africa and in the rest of the world. Furthermore, the figures for learners who did not meet the minimum expected levels for their grade recorded in these studies were strikingly similar to those obtained in the Systemic Evaluation – lending powerful support to the findings of all of the studies. Consequently, it can safely be assumed that around 80% of South African learners are below the minimum expected standard for their grade. Perhaps most disturbingly, the SACMEQ study found that, in Grade 6, an astonishing **52%** of learners in mathematics were achieving scores at the Grade 3 level or lower.

The performance of learners in the NSE on different aspects of our curriculum is particularly illuminating. When the mathematics results are analysed by learning outcome it is clear that learners perform most poorly in the basic foundational skills dealt with in Learning Outcome One – numbers, operations and relationships. None of the currently available data from the primary level suggests that we can look forward to learner improvements in performance in mathematics as the 'post-Apartheid' cohorts educated after the introduction of the new curriculum reach Grade 12.

The necessary conclusion of the data we have reviewed is that the assessment policies and practices used in our schools have failed to produce anything like a reasonable degree of 'fit' between the expected and actual performance levels of learners on a national level. Learners are routinely promoted from one grade to the next without having mastered the content and foundational competences of preceding grades, resulting in a large cognitive backlog that progressively inhibits the acquisition of more complex competencies. The consequence is that every class has become, in effect, a 'multi-grade' class in which there is a very large range of learner abilities and this makes it very difficult, or even impossible, to consistently teach to the required assessment standards for any particular grade. Mathematics, however, is an hierarchical subject in which the development of increasingly complex cognitive abilities at each succeeding level is dependent on the progressive and cumulative mastery of its conceptual frameworks, starting with the absolutely fundamental basics of place value (the base-10 number system) and the four operations (calculation).

Despite years of educational reform and innovation by the state and NGOs - and the allocation of significant levels of funding to education by both the public and private sectors - it is evident that little has been achieved in the field of primary level mathematics. Most, if not all, innovation and intervention in this area in the recent past has been theory-driven and dependent on the pre-existing pedagogic and epistemological convictions of the innovators, both local and international. These approaches, however, have manifestly failed to alleviate the core problem – underachievement at primary level leading to the erosion of the effectiveness and impact of routine education and developmental innovations alike at secondary and, ultimately, tertiary, level.

Consequently, it was decided from the start to base the PMRP upon empirical research rather than upon any particular theoretical approach. This was a deliberate decision to try an empirical research-based approach, to be inductive rather than deductive. The PMRP was, therefore, designed from the beginning to provide both an empirical investigation into the outcomes of primary mathematics education *and* to result in the production of materials based upon these findings which could themselves be evaluated. Internationally, the need for this sort of empirical approach to educational research, and to materials development, is becoming increasingly recognized.

Phase I of the PMRP

Phase I was based upon an analysis of three overlapping existing data sets. The overall set was derived from six studies, conducted in a total of 154 Schools in 35 Districts in all 9 Provinces with 7 028 randomly selected children between 1998 and 2004.

- The first set consists of the mean pre and post scores obtained by the control groups in all six studies - 4 483 children in all.
- The second set consists of scores obtained for each item by individual pupils obtained during three of the six studies between 2002 and 2004 – 4 256 scripts.
- The third set consists of the rough workings contained in the same 4 256 scripts.

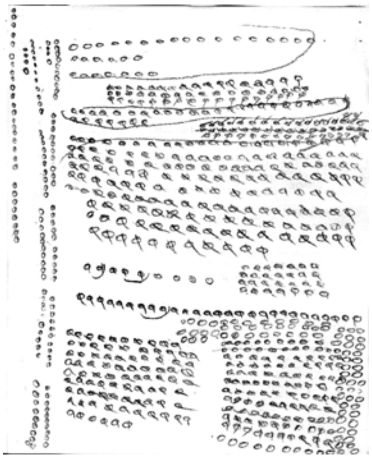
Phase I presented an analysis of the actual methods used by children to solve mathematical problems. In general, learners at all primary grade levels in all provinces routinely reduce all addition, subtraction, multiplication and division tasks to counting forwards or backwards, usually in single units. The analysis distinguished between three methods used in the solving of these problems:

- *Unit counting:* Where all kinds of problems (add, subtract, multiply, divide) are solved by reducing the numbers involved to single unit marks and counting them.
- *Repeated Operations*: Where multiplication and division problems are solved using whole numbers, but where the problems are reduced to addition and subtraction processes by repeatedly adding or subtracting the numbers involved. This is, essentially, a more complex

version of the above; the (skip) counting - as against true calculating - takes place through numbers rather than single units.
- *Calculations:* Where all kinds of problems are solved using whole numbers in the conventional way to calculate - as against count - the solutions.

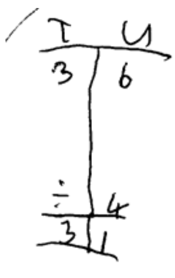
The data indicated that **79.5%** of Grade Five and **60.3%** of Grade Seven children still rely on simple unit counting to solve problems to one degree or another, while 38.1% and 11.5%, respectively, of them rely *exclusively* upon this method.

Three typical examples of learner problem-solving methods are reproduced below:



In this example, drawn from a **Grade Five** script, separate calculations are performed one by one until the page is filled; thereafter, multiple problems are solved on the same set of marks. The method is very confusing when the problem involves larger numbers and especially so when multiplication and division problems are attempted. Many mistakes occur when children attempt to tally totals. The example clearly illustrates that this method amounts to no more than an extension of counting on fingers, with unit marks substituting for fingers when numbers are larger than ten.

Here the division problem 1 420 ÷ 20 has been reduced to the repeated addition of 20 to itself until 1 420 is reached. Each time the addition is performed is ticked and the ticks become unit markings which are mechanically counted to yield the answer. It is evident that the method is not workable if fractions are involved and very confusing if large numbers are involved. It will be noted that the problem is very simply solved with a basic understanding of place value and the 2 times table. That the example is from a **Grade Seven** script underscores the point.



In this example, a **Grade Seven** learner makes an unsuccessful attempt to use a whole number calculation to solve 36 ÷ 4. The child clearly has no idea how to actually use conventional division methods, has no knowledge of times tables and, perhaps most significantly, has no number sense in that 36 divided four times simply cannot be 31.

Phase I demonstrated that the majority of South African learners are not developing any kind of understanding of the base-10 number system and the associated critical understanding of place value. They cannot mentally, or in writing, manipulate numbers, especially when they are large or contain fractions, do not readily understand the meaning of multiplication and division and cannot use the skills of borrowing and carrying upon which all more complex calculations depend. This is, in my view, clearly the single most important cause of poor learner performance in our schools.

Phase II of the PMRP

The intention of Phase II of the PMRP was to develop and rigorously field test a set of teacher manuals and learner workbooks that were based on the findings of Phase I and would seek to apply an intervention programme that would result in significant gains in learner performance. The materials were developed and drafted over 2006 and field-tested over 2007. In all, the materials provide the basis of 70 lessons over 14 weeks and have subsequently been adapted to take into account the findings of the field testing.

The most basic of the assumptions underpinning the materials is the proposition that the essential ‘bedrock’ skill of all mathematical ability is the capacity to easily perform mental calculations through formally learned processes called algorithms. The application of these algorithms allow the solving of extremely complex calculations in simple steps through an understanding and knowledge of basic number bonds, the multiplication (and division) tables and, above all, an understanding of place value in the base-10 number system. Conversely, the failure of learners to understand the number system and to master arithmetic operations beyond the reach of the simple counting of single units renders learners incapable of developing any degree of mathematical proficiency.

With respect to the process of learning itself, the findings of Phase I, as well as a great deal of both local and international research, indicated that it is increasingly apparent that ‘learner-centred’ approaches based on ’constructivism’ as a theory of learning is only workable, if at all, once basic mathematical skills have already been acquired. Further, an increasing body of research demonstrates that these basic skills are best acquired through an approach stressing direct instruction combined with extensive drill and practice and, consequently, the Phase II PMRP materials are based on this approach. Teachers would *teach* learners who would, in turn, be provided with extensive opportunities to learn and practice newly-introduced skills through many more exercises than current materials typically provide. The importance of memory; short and long term, and the complex interaction between them in learning was given close attention. The materials are based on the proposition that the development of complex cognitive comprehensions is based, in the first instance, on the fundamentals of memory. Learned facts, and sets of facts, establish a neural structure that is explored and explicated through regular applied exercises before the freedom to manipulate facts, see relationships between them and apply this understanding to problem solving can be achieved.

Phase I provided clear empirical evidence of the inability of learners to handle or manipulate numbers with any degree of competence and the NSE confirmed that the key problem area lies in a failure to achieve the assessment standards of Learning Outcome One. In particular, Phase I demonstrated that the ‘concrete’ counting methods, results of ‘discovery’ and ‘learner-centred’ approaches, combined with the perceived prohibition of memorization, drill and practice that are assumed to provide insight into the nature of mathematical operations do exactly the opposite – they ‘freeze’ learners at an exceptionally simplistic level of problem solving methods that ensures they will be unable to handle cognitively complex problems in any of the other learning outcomes – every learning outcome requires the ability to calculate!

Consequently, the materials deal only with Learning Outcome One of the National Curriculum Statement. The materials consist of complete lessons organized in detailed weekly and daily sequences. The teacher manuals provide all of the material; topics, content, methodology, required to teach LOI in the correct curriculum sequence and progression. The learner workbooks provide all of the corresponding content, drills, exercises and extensions. The lesson plans for Days One to Four for each week are based on a logical structure that supports the entire teaching, learning and assessment process of the PMRP, while Day Five provides opportunities for review, assessment, enrichment and remediation. Along with direct teacher instruction, each daily lesson provides sets of many exercises for learners to practice the content with which the lesson deals.

We have already seen that virtually all classes have become, in effect, multi grade classes in which many learners are two, three or even four grades below their required standards. Consequently, materials developed for our school system must take into account this fact; the PMRP materials do this by providing sections in the learner workbooks that cover the assessment standards from Grade 3 to Grade 6 level for each assessment standard. Learners enter the programme through a diagnostic test which measures their personal grade competency level for each of the four operations against the NCS for mathematics for Grades 3 to 6. They are subsequently directed to the learner workbook section that corresponds to that level of competency. Teacher content input in each lesson, always based on the direct instruction of an algorithm or problem-solving rule/method, is the same for all groups. However, the subsequent section of the lesson provides multiple exercises for practicing the algorithm or method in which learners work with problems based on their current level of comprehension. Results for the daily exercises are collected weekly and used as the basis of a continuous assessment system indicating when learners are ready to move on to the next level of demand in terms of the assessment standards. There are also three formal assessment points during the 14 week programme, again allowing for movement between groups.

The materials are, therefore, designed to use assessment as continual feedback on how well teachers and individual learners are achieving the required assessment standards for the different grade levels. Consequently, it should be possible for learners to progress from one grade level to the next during the course of working through the materials and it was of special interest to the field research to find out if this is possible or achievable in practice – and if the effect could be measured.

In summary, the programme materials developed in Phase II were based on five key principles derived from Phase I:

- Empirical research as the basis of materials development.
- Experimentation with a structured 'teacher-centred' approach to the learning of basic and foundational skills involving an emphasis on structured direct instruction by teachers, and the use of memorization, drill and extensive regular practice for learners, before extensions into 'learner-centred' activities (games, puzzles, etc.) are attempted.
- The need to provide a programme intervention embodying a grade-differentiated capacity allowing for teaching in classrooms where learners have widely differing levels of subject competence.
- The institutionalization of a diagnostic and formative assessment system to control the exposure of learners to the correct complexity level in practice of learned content.
- The provision to teachers of a complete syllabus of study, backed by a complete set of materials, based on the Assessment Standards of the National Curriculum Statement.

Field Testing of the PMRP Programme

The design of the field test of the materials was submitted to, adapted and approved by the National Department of Education. A total of 40 schools were identified in 3 circuits of the Vhembe District by the Circuit Managers in Malamulele North East, East and Central Circuits. The 20 schools in Malamulele North East and East are all in rural or remote areas while the 20 schools in Malamulele Central are located in or close to the more developed 'urban' area of Malamulele itself.

The measurement of programme effect on learner performance – the summative impact of the PMRP - is based on an experimental model using pre-and post-testing for randomly selected project and control groups of equal sizes.

Project	**Baseline research**	*Intervention*	**Post project research**
Control		*Routine schooling*	

The control group provides the 'counterfactual' – what would have happened to learner scores in the project group if the PMRP intervention had not occurred? Impact analysis compares the growth in mean scores between pre and post-testing achieved by the two groups – essentially, the gain of the control group is subtracted from that of the project group to measure the impact of the project intervention. The project and control groups are of equal sizes (in terms of schools/classes) to ensure that the data derived from both of them have the same sampling error with a confidence level of 95% and a precision of just under 2%. This provides reliably comparable data from both groups based on a sensitive instrument which has, in addition, a reasonably large number of items – thus increasing both sensitivity and reliability, especially in terms of percentage figures derived from raw scores.

The test instruments were constructed from a number of different sources and were divided into a number of parts. The sources of the items were:

- ❖ The items dealing with Learning Outcome One from the previous version of the National Systemic Evaluation.
- ❖ Learning Outcome One items from the instruments regularly used by ESA, and upon which Phase I was based. These instruments have long proved themselves capable of consistently delivering reliable field data about comparative learner performance.
- ❖ The development of 8 simple word sums matched to 8 operations from part 2.
- ❖ For the post-tests, 20 items dealing with the four operations were developed in the Grade 6 instrument to measure the degree of difference between groups in terms of items based on the assessment standards for Grades 5 and 4. The intention here was to provide an indicator of impact on Grade 6 learners who may not yet have reached Grade 6 standards.

Each test instrument is printed on one side of each page with the other left free for rough workings; this provided us with another indicator - based on the actual problem-solving methods used by learners. At baseline, simple counting methods overwhelmingly dominated problem-solving in both groups at both grade levels. Since a key objective of the programme was to change this situation, the design predicts that the programme would result in both:

- ❖ A significant increase (i.e. over +2%) in score of the project group over the control group between pre-and post-testing.
- ❖ A significant difference in the frequency of calculation methods, as against counting methods, in the project over the control group by the end of the programme.

The selected schools were randomly divided into project and control groups. Grades 4 and 6 were chosen because the materials are directed to the Intermediate Phase, though they do start from the Grade 3 assessment standards, for obvious reasons. At each school, the whole class of each participating teacher was tested and lesson observations carried out in their classes, interviews with these teachers and with the principals were also completed. The testing provided the data against which impact on learner performance would be measured, while the observations and interviews were primarily concerned with ensuring that the project and control groups were reasonably well matched with regard to factors like socio economic status, supply of materials, presence of other intervention projects, existing classroom methods, work scheduling and curriculum management, level of drill and practice demanded of learners, frequency and level of applied games, puzzles and so on. In this regard, there were no consistent differences between the project and control groups at baseline and they were very similar to each other – idiosyncratic differences at individual schools in both groups not withstanding.

At each test session, administered by ESA field-researchers resident in the area and monitored by senior researchers, the questions were translated into mother-tongue, almost always isiTsonga with some isiVenda, and learners could also ask for translation at any time during the test. No other assistance was provided and learners were allowed only a pen or pencil to complete the instrument – no scrap paper was provided and the use of calculators was forbidden and closely monitored. Strict control was maintained over the instruments and all were accounted for after baseline testing.

Programme Delivery

The principal, HoD and both teachers from each project school were invited to a training workshop lasting one and a half days covering the design and use of the teacher and learner materials in classrooms. Teachers received personal copies of the Teacher Manual and sufficient copies of the Learner workbooks for their whole class. In addition, each teacher received copies of the diagnostic test instrument for all of their learners and personal copies of continuous assessment record sheets. One week after the training workshop, each teacher received a school visit from a senior researcher; the focus of this visit was to ensure that the diagnostic test had been administered and interpreted correctly, as well as ensuring that the teacher had commenced using the programme in classrooms. Approximately half way through the programme (i.e. 7 weeks) each teacher was again visited; this time the focus was on the experience of using the materials on a daily basis.

Teachers were invited to act as teacher-researchers throughout the period and provided with a research diary. They were asked to keep notes about what was happening, ideas for improvements, criticisms and reflections, and so on. While only a minority of teachers did actually keep this up for most of the period, their comments were exceptionally useful. This practice helped convince all of the teachers that the study was concerned with the effectiveness of the materials in improving learner performance, rather than with the personal quality of the teacher her/himself. Finally, schools were asked once during the 14 week period to submit a report on progress to their respective circuit managers.

The degree of programme coverage achieved by the teachers was of great importance to the field testing of the materials. We were not evaluating the organizational efficiency of ESA and the DoE in implementing a given programme intervention but rather trialling the effectiveness of the approach embodied in the materials in achieving impact on learner performance. Since these materials are based on a sequential and cumulative approach to the teaching and learning of mathematical content, it was essential to know the level of exposure of learners to the full ‘treatment’. In clinical trials of new drugs, where control over exposure to the intervention is very much higher, the level of exposure of patients to the treatment is critical to deciding questions of impact (i.e. effectiveness of the treatment being trialled.) Consequently, the impact tables that follow report the figures in relation to the degree of programme coverage achieved; first for the whole sample without regard to coverage, second for learners receiving at least half of the programme (7 weeks) and finally for learners receiving at least 80% of the programme (11 weeks).

Programme coverage: n of project group schools

	Grade 4	Grade 6
Whole sample: irrespective of coverage	20	18
Minimum of 7 weeks coverage	16	16
Minimum of 11 weeks coverage	12	9

Impact on Learner Performance

Post-project research was conducted in the second and third weeks of November to give the teachers as much time as possible to complete the programme. Another full round of qualitative research was also carried out in all of the schools; principal and teacher interviews and lesson observations. This research confirmed that the only significant change in the groups since baseline was the implementation and effects of the PMRP.

Schools and learners: post-project research (n)

	Grade 4		Grade 6		Total	
	Learners	Schools	Learners	Schools	Learners	Schools
Project Group	860	20	700	18	1 560	38
Control Group	740	19	732	20	1 472	39
Total	1 600	39	1 432	38	3 032	

In the tables that follow, impact refers to the change that can be confidently ascribed to intervention effect rather than to chance or other variables.

- ❖ The *Change in % points* rows refer to the absolute change in score between pre and post-testing expressed in percentage points, i.e. the actual amount by which the score changed for that group; a positive (+) symbol indicates that the score has increased since baseline, a negative (-) symbol the opposite.
- ❖ The *% increase on baseline* rows refer to the extent of the increase between pre and post-testing expressed as a proportion of the baseline score of that group. Again, a positive (+) symbol indicates that the score has increased since baseline, a negative (-) symbol the opposite.
- ❖ The **Impact: % points** rows refer to the *difference* in the change in score of the project and control groups measured in % points. Here a positive (+) symbol indicates that the gain in score of the project group has exceed that of the control group.
- ❖ The **Impact: % increase** rows refer to the *difference* in the change in score of the project and control groups measured by % increase over the baseline score. Again, a positive (+) symbol indicates that the gain of the project group has exceed that of the control group

The first set of tables report the results obtained for both grades in relation to the mean of the whole test while later tables deal with the different parts of the test.

Impact on learner performance: uncontrolled for coverage (%)

	Grade 4	**Grade 6**
Project Group		
Baseline	17.93	15.32
Post Test	30.27	28.91
Change in % points	*+12.34*	*+13.59*
% increase on baseline	*+68.82*	*+88.71*
Control Group		
Baseline	15.59	12.03
Post Test	18.54	15.03
Change	*+2.95*	*+3.0*
% increase on baseline	*+18.92*	*24.94*
Impact: % points	**+9.39**	**+10.59**
Impact: % increase	**+49.90**	**+63.77**

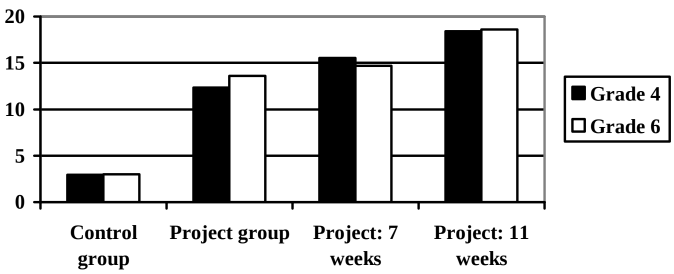
These impact figures provide clear evidence of significant intervention effect well beyond the statistical significant threshold of +2%. Since the table is based on all of the data for both groups uncontrolled for the extent of programme coverage and makes no distinction between data from schools where learners may have received as little as 3 or 4 weeks (21% or 28%) exposure and those where learners have received over 11 weeks (80%) exposure, this is clearly the 'worst case scenario and it can reasonably be assumed that the figures in this table represent the lowest level of impact likely to be achieved by the programme in future. To provide some idea of the relative educational and socioeconomic significance of these figures, reference is made to a recent study which provided a summary of 20 evaluations dealing with mathematics interventions. Only one of these interventions reliably measured an impact in one of the Grades close to that of the PMRP in percentage points (+9.2%), and the mean of +1.12% is far below the mean of 9.99% for both grades for the PMRP. It is important to note that all of these studies were of programmes that were applied for very much longer than the 14 weeks of the PMRP - one of them, for example, operated for 5 years while another operated for 4 years - whatever effects they achieved took much longer to achieve at a much higher cost. The clear implication is that significant change in learner performance in mathematics need not take years to achieve if the appropriate approach and methods are applied.

Impact on learner performance: controlled for coverage: 11 weeks (%)

	Grade 4	**Grade 6**
Project		
Baseline	18.09	14.68
Post Test	36.48	33.28
Change	*+18.39*	*+18.60*
% increase on baseline	*+101.66*	*+126.70*
Control		
Baseline	15.59	12.03
Post Test	18.54	15.03
Change	*+2.95*	*+3.0*
% increase on baseline	*+18.92*	*+24.94*
Impact: % points	**+15.44**	**+15.60**
Impact: % increase	**+82.74**	**+101.76**

These figures provide the most reliable measurement of the impact of the approach and methodology of the PMRP programme in that learners have been exposed to a reasonably complete degree of coverage of the programme. There is over 80% improvement in baseline scores at Grade 4 and over 100% at Grade 6. Whether expressed as a greater gain in the project group in percentage points, or as a greater gain in increase over the initial baseline score, the figures are all evidence of genuinely significant improvements in learner performance that can confidently ascribed to the PMRP.

Summary of % point gain between baseline and post-testing



The graph very clearly illustrate the effect of increasing degrees of completeness of programme coverage; it also illustrates the critical nature of generic issues of completeness of curriculum coverage in schools in general.

We have already noted that the test instrument is divided into a number of parts, each dealing with a different element of Learning Outcome One. All the ‘controlled’ figures in the tables that follow are derived from schools that completed at least 11 weeks (80%) of the programme intervention in classrooms; the 50% category has been excluded for the sake of brevity.

Part 1: LO1 items from the previous version of the NSE instruments (%)

	Grade 4	**(12 items)**	**Grade 6**	**(16 items)**
	Uncontrolled	**Controlled**	**Uncontrolled**	**Controlled**
Project				
Baseline	23.17	21.58	20.19	18.50
Post Test	30.00	36.83	25.38	32.12
Change	*+6.83*	*+15.25*	*+5.19*	*+13.62*
% increase on baseline	*+29.50*	*+70.67*	*+25.70*	*+73.62*
Control				
Baseline	23.42	23.42	17.75	17.75
Post Test	17.92	17.92	19.75	19.75
Change	*-5.50*	*-5.50*	*+2.0*	*+2.0*
% increase on baseline	*-23.48*	*-23.48*	*+11.27*	*+11.27*
Impact: % points	**+12.33**	**+20.75**	**+3.19**	**+11.62**
Impact: % increase	**+52.98**	**+94.15**	**+14.43**	**+62.35**

Whether controlled for coverage or not, all of the impact measures are significant beyond the threshold of +2% in percentage points. Since the NSE instrument covers the whole of LO One it is not surprising that the scores controlled for 80% of coverage are dramatically better – the learners have covered much more of LO One in the programme. These scores are especially significant in that they are derived from items that have been used by the DoE itself in national testing and that cannot be said to be biased toward the PMRP programme.

Part 2: Operations items from ESA instrument

	Grade 4	**(20 items)**	**Grade 6**	**(20 items)**
	Uncontrolled	**Controlled**	**Uncontrolled**	**Controlled**
Project				
Baseline	20.75	22.15	17.05	17.35
Post Test	35.80	40.20	35.25	41.35
Change	*+15.05*	*+18.05*	*+18.20*	*+24.00*
% increase on baseline	*+72.53*	*+81.49*	*+106.74*	*+138.33*
Control				
Baseline	18.35	18.35	13.35	13.35
Post Test	23.90	23.90	17.10	17.10
Change	*+5.55*	*+5.55*	*+3.75*	*+3.75*
% increase on baseline	*+30.24*	*+30.24*	*+28.09*	*+28.09*
Impact: % points	**+9.50**	**+12.50**	**+14.45**	**+20.25**
Impact: % increase	**+42.29**	**+51.25**	**+78.65**	**+110.24**

This part of the test dealt with the four operations at the relevant assessment standards and the gains are again obvious, especially for the controlled scores. There can be no doubt that the ability of learners to deal with operations problems was very significantly improved over the course of the programme; even the uncontrolled gain scores are high. Since this was a major objective of the programme that was clearly achieved, it can be assumed that the ability of learners to handle any type of question involving a calculation should also improve and the next two tables lend strong support to this assumption, as do the figures for the NSE items in Part 1.

Part 3: Generic LO1 items from ESA instrument (%)

	Grade 4	**(11 items)**	**Grade 6**	**(22 items)**
	Uncontrolled	**Controlled**	**Uncontrolled**	**Controlled**
Project				
Baseline	14.91	14.91	10.43	10.70
Post Test	29.45	36.73	18.64	22.68
Change	*+14.54*	*+21.82*	*+8.21*	*+11.98*
% increase on baseline	*+97.52*	*+146.34*	*+78.71*	*+111.96*
Control				
Baseline	12.64	12.64	8.26	8.26
Post Test	16.36	16.36	9.27	9.27
Change	*+3.72*	*+3.72*	*+1.01*	*+1.01*
% increase on baseline	*+29.43*	*+29.43*	*+12.23*	*+12.23*
Impact: % points	**+10.82**	**+18.10**	**+7.20**	**+10.97**
Impact: % increase	**+68.09**	**+116.91**	**-66.48**	**+99.73**

As predicted, learners in project schools performed well on this component of the instrument which essentially extends Part 1 (NSE items). The items dealt with shapes, fractions, conversions, relationships, sequences and factors. Besides the content instruction and practice they received, they were also simply more able to carry out any required calculations and were much more aware of place value in any kind of number manipulation.

Part 4: Word sums involving the extraction and solving of basic operations

	Grade 4	**(8 items)**	**Grade 6**	**(8 items)**
	Uncontrolled	**Controlled**	**Uncontrolled**	**Controlled**
Project				
Baseline	9.37	9.00	10.62	9.87
Post Test	22.25	28.75	24.37	27.5
Change	*+12.88*	*+19.75*	*+13.75*	*+17.63*
% increase on baseline	*+137.33*	*+219.44*	*+129.47*	*+178.62*
Control				
Baseline	7.12	7.12	7.25	7.25
Post Test	12.12	12.12	7.62	7.62
Change	*+5.00*	*+5.00*	*+0.37*	*+0.37*
% increase on baseline	*+70.22*	*+70.22*	*+5.10*	*+5.10*
Impact: % points	**+7.88**	**+14.75**	**+13.38**	**+17.26**
Impact: % increase	**+67.11**	**+149.22**	**+124.37**	**+173.52**

These figures are very significant indeed for both the controlled and uncontrolled data. These large increases in ability to solve word sums involved two factors; first an ability to extract the calculation from the language problem (semantic understanding) and, second, an ability to actually perform the calculation. The programme does lay stress on understanding that sentences like ‘how many sweets does each child have’ involve a division calculation, and so on. This, coupled with their regular practice of word sums and calculations in general, has improved their ability well beyond that of the control group exposed to a different approach.

The next table deals with the component of the instrument that was added for Grade 6 at post-testing; the (20) items deal with the four operations based on the assessment standards for the two previous grades.

Part 5: Operations covering the Assessment Standards for Grades 4 and 5: Grade 6 only (%)

	Uncontrolled	**Controlled**
Project	38.5	45.1
Control	17.5	17.55
Difference	+21.0	+27.55

Once again the impact is very significant in both controlled and uncontrolled data. This clearly demonstrates the effectiveness of materials in improving learner performance on assessment standards *prior* to the grade level in which they find themselves. This feature is essential in terms of multi-grade classes in which many of the learners are far below required competency levels; it is essential that all learners in multi-grade classes can improve even if they cannot reach the standards for the grade in which they are enrolled.

Learner Performance in the Four Operations

The next two tables analyze the data in terms of each of the four operations in Part 2 of the instrument. In general, we knew that scores nationally for addition and subtraction are relatively much higher than those for multiplication and division because of the greater ease of using simple unit counting methods to solve them. In the event, the impact on learner performance in all of the operations was significant but this improvement was most marked in multiplication and division. The full set of figures is provided for multiplication only – all of the operation s are reported in the report proper.

Impact on performance on multiplication problems (%)

	Grade 4	**(5 items)**	**Grade 6**	**(5 items)**
	Uncontrolled	**Controlled**	**Uncontrolled**	**Controlled**
Project				
Baseline	7.40	7.00	2.80	2.20
Post Test	20.20	23.80	15.80	22.00
Change	*+12.80*	*+16.80*	*+13.00*	*+19.80*
% increase on baseline	*+172.97*	*+240.00*	*+464.29*	*+900.00*
Control				
Baseline	6.80	6.80	1.40	1.40
Post Test	10.60	10.60	2.60	2.60
Change	*+3.80*	*+3.80*	*+1.20*	*+1.20*
% increase on baseline	*+55.88*	*+55.88*	*+85.71*	*+85.71*
Impact: % points	**+9.0**	**+13.00**	**+11.80**	**+18.60**
Impact: % increase	**+117.09**	**+184.12**	**+378.58**	**+814.29**

These figures are unequivocal in providing evidence of really significant impact in multiplication. While the huge figures for % increase over baseline are obviously affected by the very small base from which they are calculated, the relative *differences* between project and control groups are unaffected – both groups started from a very small base and the project group improved enormously relative to the controls. It is not really surprising that this should be so – the PMRP made a concerted effort to curtail the use of unit counting, and increase the level of memorization, drill and retrieval of the times tables, as well as borrowing and carrying (place value. There can be no serous doubt that this approach is far more effective enabling learners to easily perform multiplication (and division) problems quickly and accurately – learners have actually learned to calculate.

School Level Analysis: Distribution of Impact

Nick Taylor has commented:
"The first major lesson to emerge from intensive activity over the last two decades aimed at improving teaching and learning in poorly performing schools, is that only a fraction of such schools are amenable to improvement. The remainder have a propensity to absorb all resources directed towards them, without showing any signs of the slightest improvement. If … school improvement initiatives … were able to select only those schools which are amenable to improvement, the mean gains would be many orders of magnitude higher, and these would be achieved at a fraction of the cost." (Schools, Skills and Citizenship. JET, 2006.

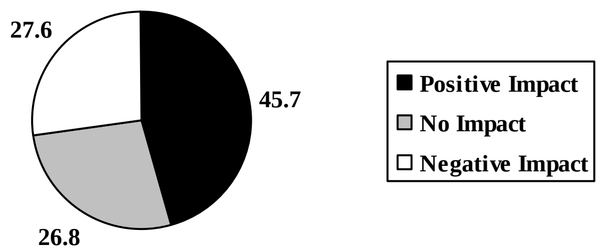
Note that the mean of gain scores in the two tables that follow are calculated by taking a mean of the school/grade mean scores, whereas the impact tables above calculate the school/grade means against the n of individual learners.

Distribution of impact: uncontrolled for programme coverage

	Grade 4 (n:20 schools)	Grade 6 (n:18 schools)
Change greater than +2% (+ve impact)	18 = 90%	17 = 94.4%
Change between +2% and -2% (no impact)	1 = 5%	0
Change lower than -2% (-ve impact)	1 = 5%	1 = 5.6%
Range of gains in school mean scores (%)	+23.91 to -8.1	+27.78 to -3.80
Mean of school gain scores (%)	+12.45	+13.80

Using +2% as the threshold of statistical significance, **90%** of the schools indicated positive impact on learner performance, while only one (5%) registered no impact at Grade 4 level and one registered negative impact at Grades 4 and 6 levels respectively. These proportions of schools providing evidence of, at least, statistically significant impact are well beyond those obtained in studies of other intervention programmes. The performance of the PMRP in this regard can be gauged by comparing the data with derived from another study of a programme dealing with mathematics at Grades 3 and 6 levels in 3 provinces that has lasted for 3 years.

Distribution of Impact by % of schools/grades: Project X



The very much better performance of the PMRP programme in achieving positive impact across a large proportion of the participating schools is obvious. This is even more true once we control the project scores for programme coverage; once half of the programme is applied all of the schools record a gain in mean score well over +2%, in fact none of these schools/grades recorded a gain lower than **+5.5%**.

Distribution of impact: controlled for programme coverage

	Grade 4 (n:20 schools)		Grade 6 (n:18 schools)	
	50% coverage	80% coverage	50% coverage	80% coverage
Schools	16 = 80%	12 = 60%	16 = 88.8%	9 = 50%
Range of gain scores (%)	+23.91 to +6.23	+23.91 to +12.68	+27.78 to +5.5	27.78 to 13.26
Mean of gain scores (%)	+15.77%	+18.39	+15.38	+21.26

When the scores are controlled for coverage of at least 11 weeks, none of the schools recorded a gain lower than **+12.68%**.

Problem Solving Methods

Firstly, let us recall that the discussion of the research design stated two central predicted impacts:

- A significant increase (i.e. over +2%) in score of the project group over the control group between pre-and post-testing.
- A significant difference in the frequency of calculation methods, as against counting methods, in the project over the control group by the end of the programme.

We have seen that the first objective has been achieved. Given the theoretical basis of the programme, it would be very surprising indeed if the second were not also achieved. Phase I of the PMRP concluded that the inability of learners to perform calculations, especially using larger number numbers, caused by a near-total reliance on simplistic counting methods was the central problem inhibiting the development of more complex cognitive competencies in mathematics. A sample of 50% of the completed scripts was chosen at random (every second test) from a sample of 50% of the schools, also randomly selected (every second school). Each script was analysed in terms of both individual learners (scripts) and the proportion of types of methods against the total number of workings in the same scripts; the first tells us what proportion of learners rely on the different methods, the second the global proportions of each method used in classrooms.

Frequency of methods used: % of scripts

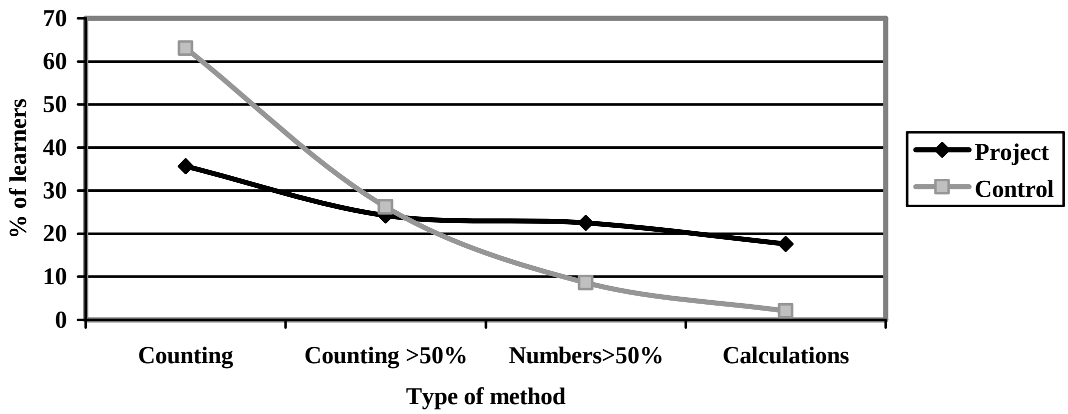
	Grade 4	Grade 6
Project		
Unit counting only	35.7	3.2
Unit counting used in over half of all workings	24.2	3.2
Whole numbers used in over half of all workings	22.5	33.7
Whole numbers only	17.6	59.9
Control		
Unit counting only	63.1	37.7
Unit counting used in over half of all workings	26.2	14.7
Whole numbers used in over half of all workings	8.6	36.6
Whole numbers only	2.1	10.9

The evidence of significant impact on the types of methods learners use is striking; at Grade 4 level **35.7%** of learners in project schools rely exclusively on unit counting as against the **63.1%** in control schools; the comparable figures for Grade 6 are equally compelling: **3.2%** as against

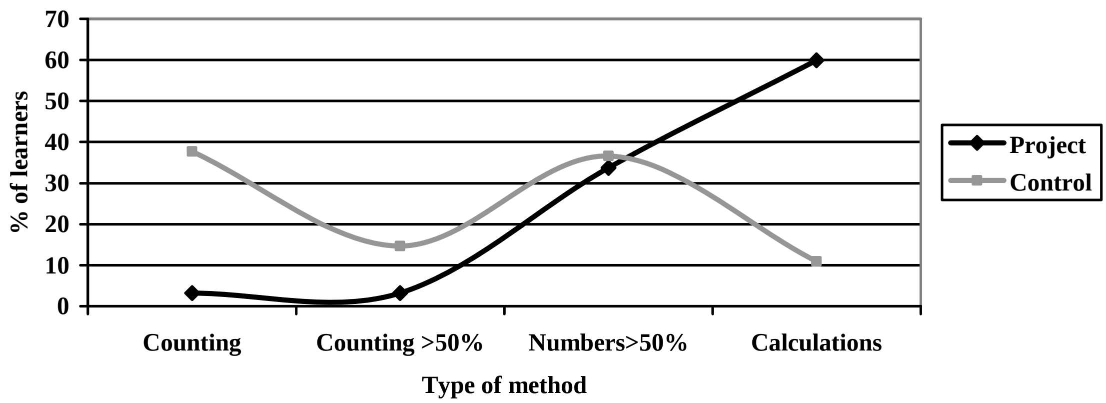
37.7%. Conversely, **17.6%** of learners at Grade 4 level in project schools work exclusively in whole numbers as against the **2.1%** in control schools and the Grade 6 figures are again significantly better: **59.9%** as against **10.9%**.

These figures provide strongly supportive evidence that the PMRP has succeeded in altering the pattern of learning solving methods employed by learners in project schools – they are far more capable of performing conventional calculations than are the learners in the control schools.

Frequency of methods used: Grade 4 (learners)



Frequency of methods used: Grade 6 (learners)



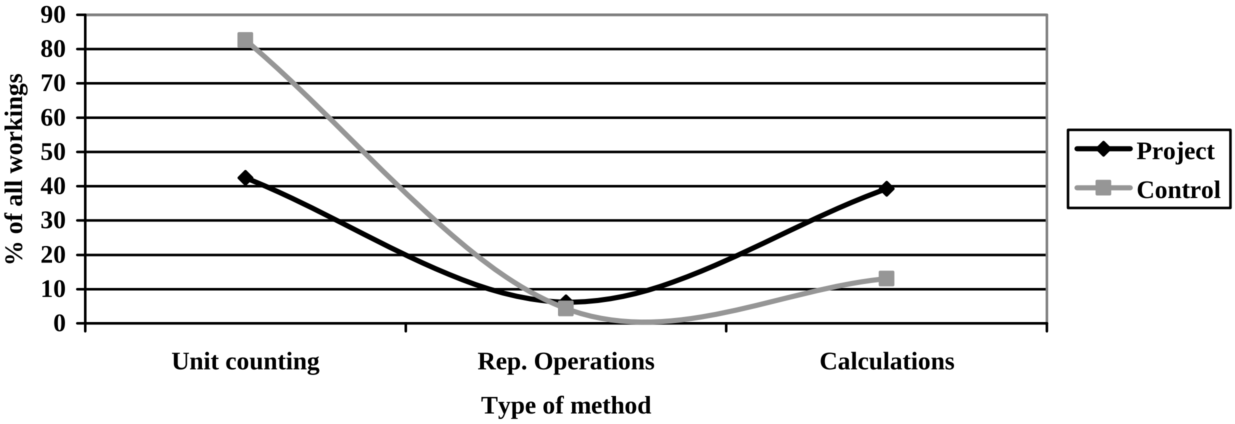
The second analysis compares types of workings against the global totals for all workings.

Frequency of methods used: % of all workings

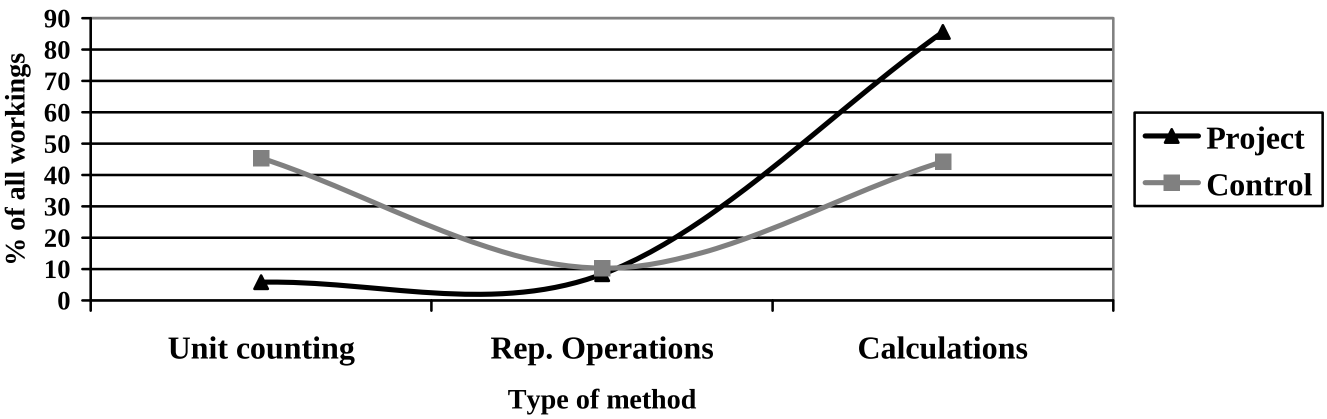
	Grade 4	Grade 6
Project		
Unit counting	42.4	5.8
Whole number repeated operations	6.2	8.4
Whole number calculations	39.3	85.6
Control		
Unit counting	82.6	45.4
Whole number repeated operations	4.3	10.3
Whole number calculations	13.1	44.3

Once gain, the evidence is clear and unambiguous. While **<u>42.2%</u>** of all the workings used by learners in project schools at Grade 4 level employed unit counting, the figure for the control schools was a staggering **<u>82.6%</u>** and the comparable figures for Grade 6 are **<u>5.8%</u>** and **<u>45.4%</u>**. Conversely, **<u>39.3%</u>** of all problems solved by learners at Grade 4 level in project schools used whole number calculations as against the **<u>13.1%</u>** in control schools and the Grade 6 figures are again significantly better – **<u>85.6%</u>** as against **<u>44.3%</u>**.

Frequency of methods used: Grade 4 (problems)



Frequency of methods used; Grade 6 (problems)



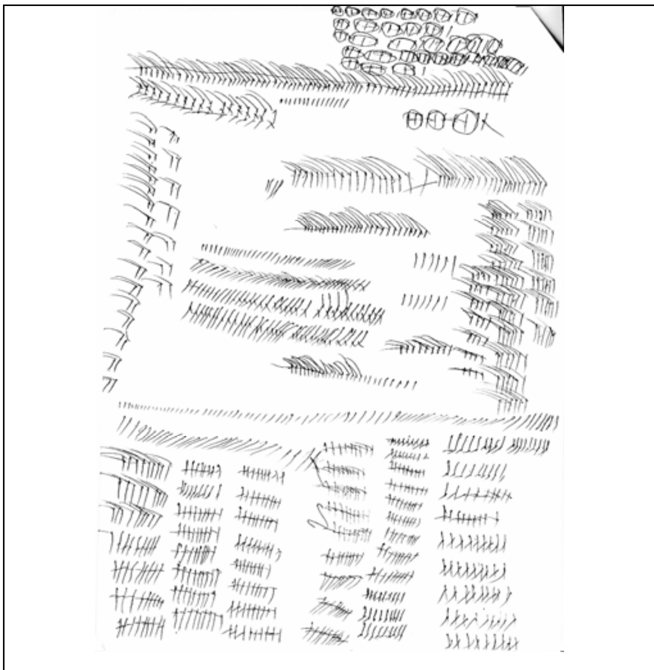
All of the data presented provides clear and consistent evidence of the achievement of the objectives of the PMRP against the key summative impact indicators; learner scores have genuinely improved across a large proportion of the sample and problem solving methods have changed dramatically. Consequently, it is safe to conclude that the validity of the theoretical design and methodological application of the PMRP programme has received strong empirical support, far beyond the threshold of statistical significance, in improving levels of learner performance in mathematics in Intermediate Phase.

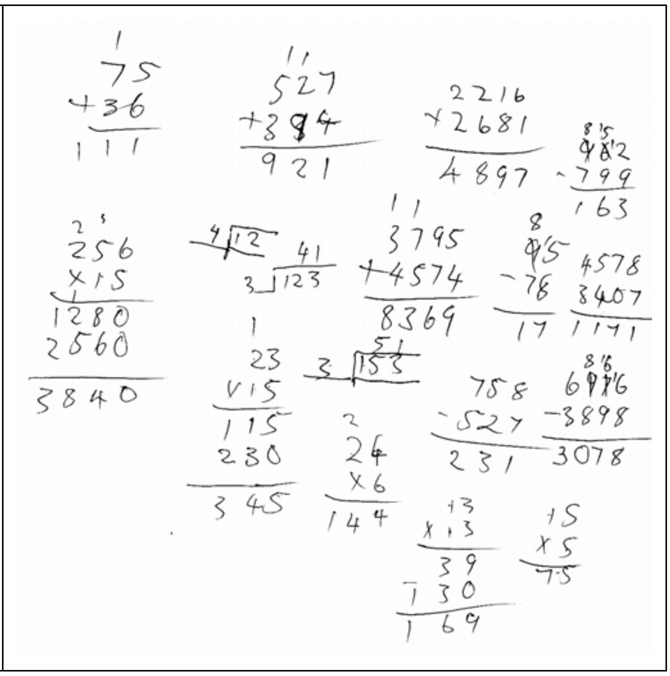
That these figures were achieved over 14 weeks is very significant indeed – the clear implication is that it need not take years to improve primary level mathematics if an effective approach is employed in doing so. Finally, it is self evident that a short programme such as this costs very much less than the 3, or more, years typical of most intervention programmes in primary level mathematics.

APPENDIX ONE

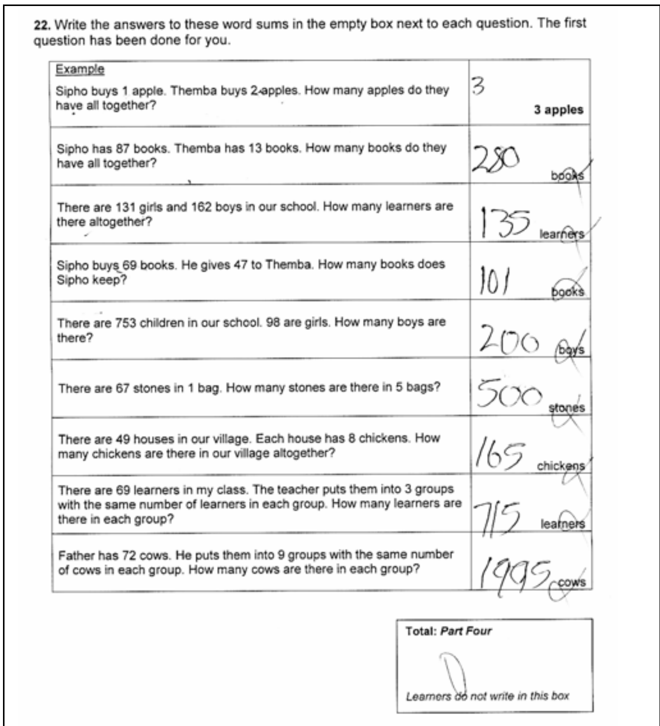
SCANS OF LEARNER SCRIPTS

These scans are all drawn from scripts competed by learners at post testing and are presented to illustrate the figures presented in the main body of the report.





These examples are both drawn from Grade 6 scripts, the first from learner in a control school uses only unit markings while the second from a project school uses only whole number calculations.

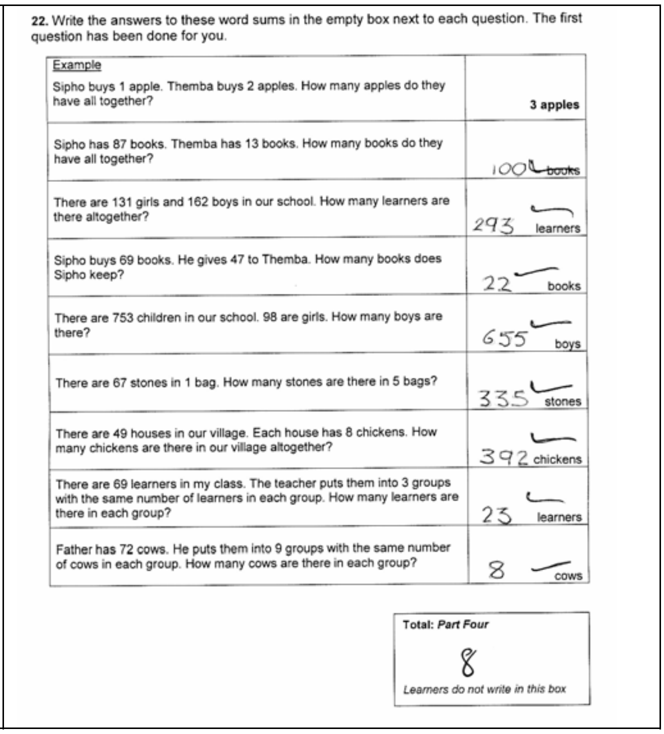


22. Write the answers to these word sums in the empty box next to each question. The first question has been done for you.

Example Sipho buys 1 apple. Themba buys 2 apples. How many apples do they have all together?	3 **3 apples**
Sipho has 87 books. Themba has 13 books. How many books do they have all together?	280 books
There are 131 girls and 162 boys in our school. How many learners are there altogether?	135 learners
Sipho buys 69 books. He gives 47 to Themba. How many books does Sipho keep?	101 books
There are 753 children in our school. 98 are girls. How many boys are there?	200 boys
There are 67 stones in 1 bag. How many stones are there in 5 bags?	500 stones
There are 49 houses in our village. Each house has 8 chickens. How many chickens are there in our village altogether?	165 chickens
There are 69 learners in my class. The teacher puts them into 3 groups with the same number of learners in each group. How many learners are there in each group?	715 learners
Father has 72 cows. He puts them into 9 groups with the same number of cows in each group. How many cows are there in each group?	1995 cows

Total: ***Part Four***

Learners do not write in this box



22. Write the answers to these word sums in the empty box next to each question. The first question has been done for you.

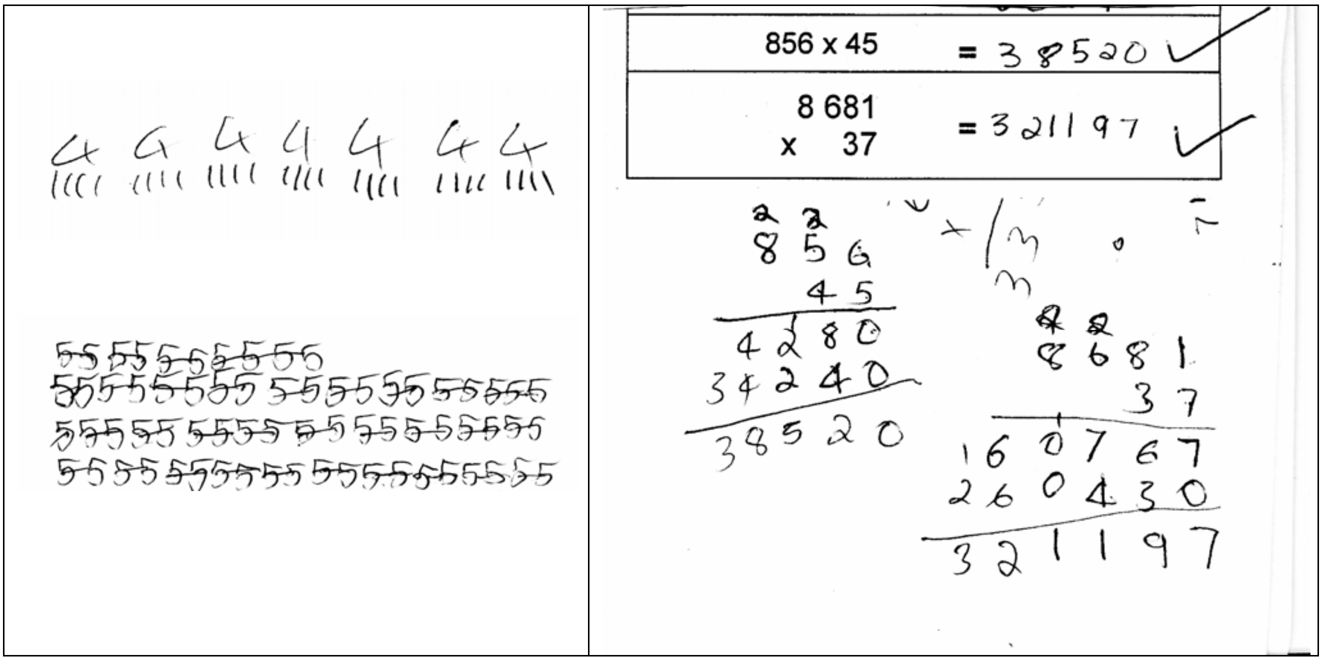
Example Sipho buys 1 apple. Themba buys 2 apples. How many apples do they have all together?	**3 apples**
Sipho has 87 books. Themba has 13 books. How many books do they have all together?	100 books
There are 131 girls and 162 boys in our school. How many learners are there altogether?	293 learners
Sipho buys 69 books. He gives 47 to Themba. How many books does Sipho keep?	22 books
There are 753 children in our school. 98 are girls. How many boys are there?	655 boys
There are 67 stones in 1 bag. How many stones are there in 5 bags?	335 stones
There are 49 houses in our village. Each house has 8 chickens. How many chickens are there in our village altogether?	392 chickens
There are 69 learners in my class. The teacher puts them into 3 groups with the same number of learners in each group. How many learners are there in each group?	23 learners
Father has 72 cows. He puts them into 9 groups with the same number of cows in each group. How many cows are there in each group?	8 cows

Total: ***Part Four***

8

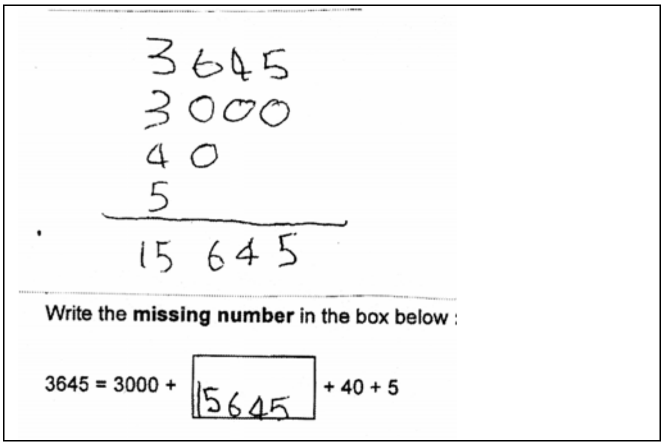
Learners do not write in this box

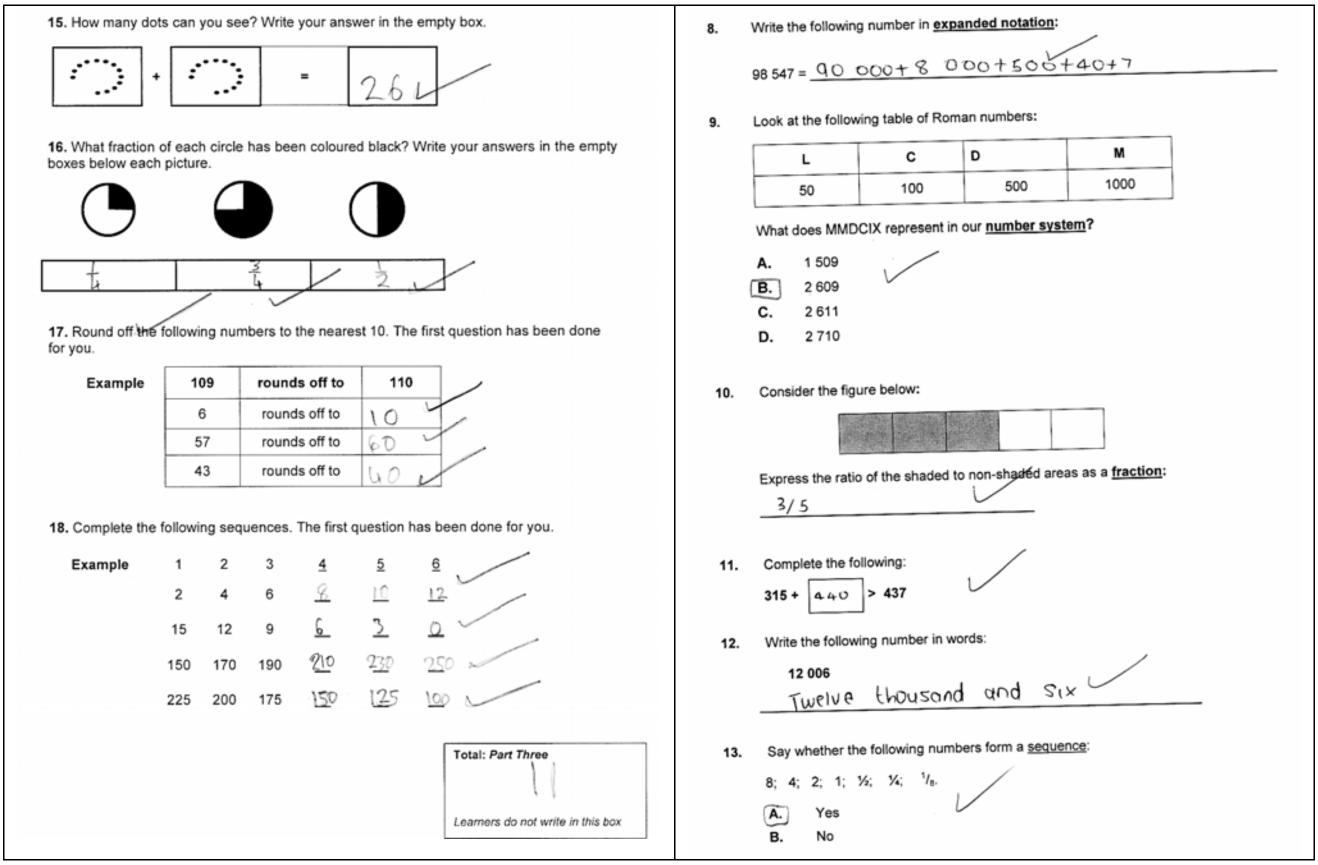
These examples, both from Grade 6, illustrate the gap in the ability to solve word sums by the end of the project; the first is from a learner in a control school, the second from a project school.



All of these examples are from Grade 6 scripts. The two on the left typify methods used by learners in control schools to solve multiplication problems. The first is 4 x 7 where 4 is repeated 7 times and then reduced to units which are counted to arrive at the answer. The second is 5 x 67 in which 5 is repeated 67 times and them added to itself to arrive at the answer. The one of the right, by contrast, is from a project school in which complex problems (856 x 45 and 8 681 x 37) are solved correctly through knowledge of the algorithm combined with a mastery of the times tables and place value.

Compare the ability to control place value by the project learner, above with a corresponding inability to do so by another Grade 6 learner in a control school, below. The item itself appears in Part One of the instrument and is drawn from the National Systemic Evaluation instrument.





15. How many dots can you see? Write your answer in the empty box.

[dots] + [dots] = 26

16. What fraction of each circle has been coloured black? Write your answers in the empty boxes below each picture.

1/4	3/4	1/2

17. Round off the following numbers to the nearest 10. The first question has been done for you.

Example	109	rounds off to	110
	6	rounds off to	10
	57	rounds off to	60
	43	rounds off to	40

18. Complete the following sequences. The first question has been done for you.

Example	1	2	3	4	5	6
	2	4	6	8	10	12
	15	12	9	6	3	0
	150	170	190	210	230	250
	225	200	175	150	125	100

Total: *Part Three*
11
Learners do not write in this box

8. Write the following number in **expanded notation**:

98 547 = 90 000+8 000+500+40+7

9. Look at the following table of Roman numbers:

L	C	D	M
50	100	500	1000

What does MMDCIX represent in our **number system**?

A. 1 509
B. 2 609
C. 2 611
D. 2 710

10. Consider the figure below:

Express the ratio of the shaded to non-shaded areas as a **fraction**:

3/5

11. Complete the following:

315 + 440 > 437

12. Write the following number in words:

12 006

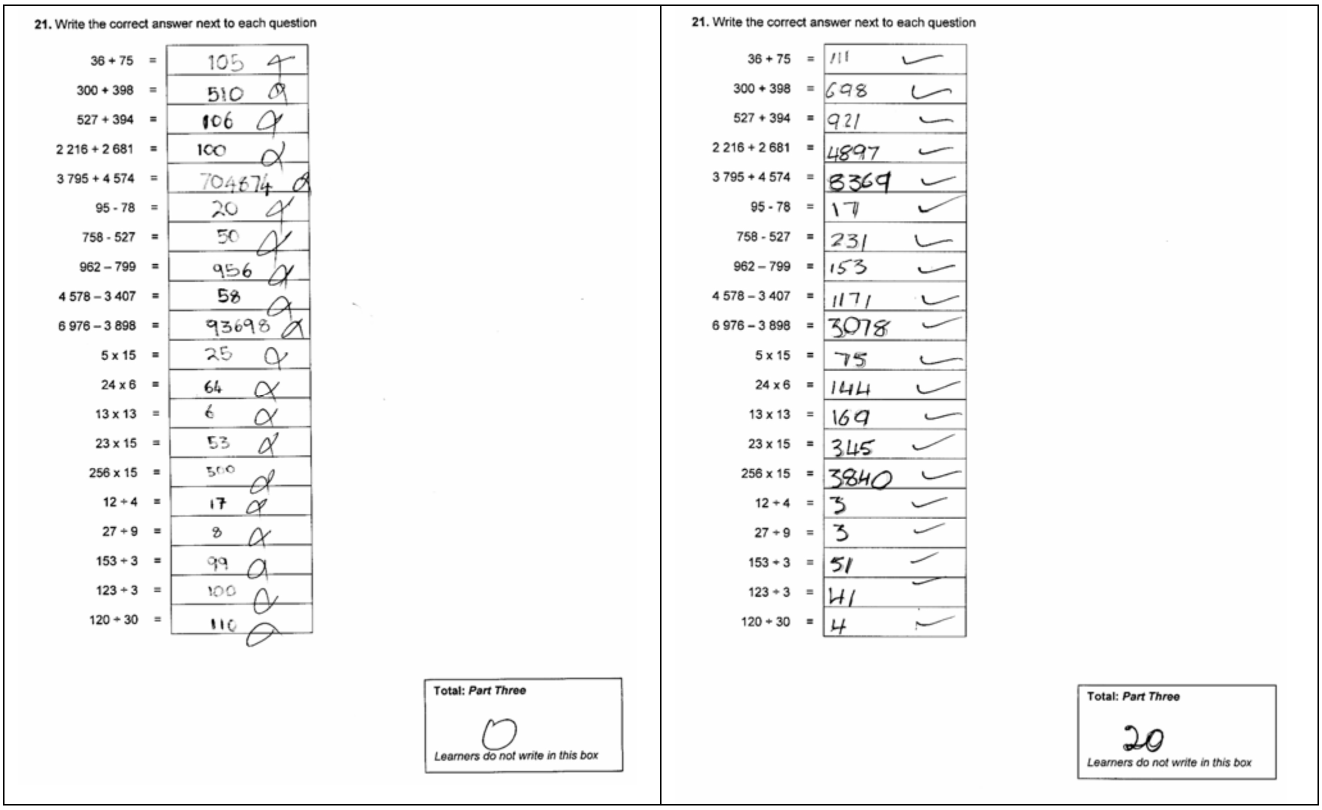
Twelve thousand and six

13. Say whether the following numbers form a **sequence**:

8; 4; 2; 1; ½; ¼; ⅛.

A. Yes
B. No

Here learners from project schools in Grade 4 are able to answer questions correctly from Part 2 (ESA genericLO1) and Part 1 (NSE LO1), respectively.

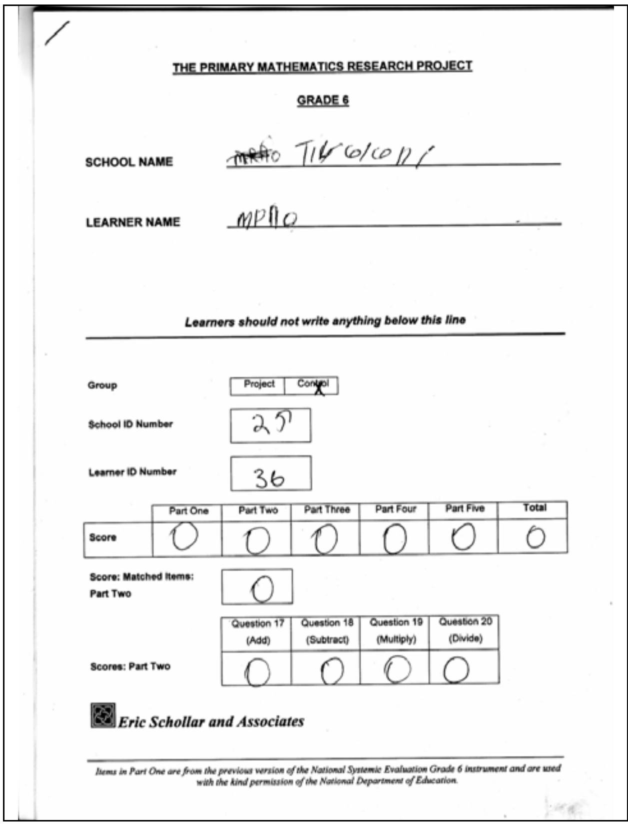


21. Write the correct answer next to each question

		Control	Project
36 + 75	=	105	111
300 + 398	=	510	698
527 + 394	=	106	921
2 216 + 2 681	=	100	4897
3 795 + 4 574	=	704674	8369
95 - 78	=	20	17
758 - 527	=	50	231
962 – 799	=	956	153
4 578 – 3 407	=	58	1171
6 976 – 3 898	=	93698	3078
5 x 15	=	25	75
24 x 6	=	64	144
13 x 13	=	6	169
23 x 15	=	53	345
256 x 15	=	500	3840
12 ÷ 4	=	17	3
27 ÷ 9	=	8	3
153 ÷ 3	=	99	51
123 ÷ 3	=	100	41
120 ÷ 30	=	110	4

Total: *Part Three* 0 (control) / 20 (project)
Learners do not write in this box

These examples are both drawn from Grade 6 learners and illustrate performance on Part 5 – operations based on the assessment standards for Grades 4 and 5. The first is from a control school, the second from a project schools.


THE PRIMARY MATHEMATICS RESEARCH PROJECT

GRADE 6

SCHOOL NAME [illegible]

LEARNER NAME MPhO

Learners should not write anything below this line

Group	Project	Control

School ID Number: 27

Learner ID Number: 36

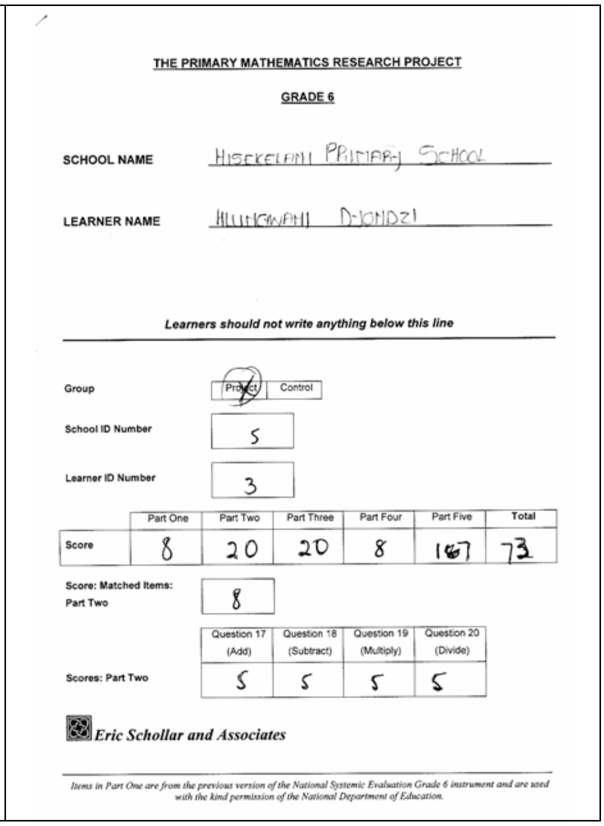
	Part One	Part Two	Part Three	Part Four	Part Five	Total
Score	0	0	0	0	0	0

Score: Matched Items: Part Two: 0

	Question 17 (Add)	Question 18 (Subtract)	Question 19 (Multiply)	Question 20 (Divide)
Scores: Part Two	0	0	0	0

Eric Schollar and Associates

Items in Part One are from the previous version of the National Systemic Evaluation Grade 6 instrument and are used with the kind permission of the National Department of Education.


THE PRIMARY MATHEMATICS RESEARCH PROJECT

GRADE 6

SCHOOL NAME HISEKELANI PRIMARY SCHOOL

LEARNER NAME HLUNGWANI DHLONDZI

Learners should not write anything below this line

Group	Project	Control

School ID Number: 5

Learner ID Number: 3

	Part One	Part Two	Part Three	Part Four	Part Five	Total
Score	8	20	20	8	17	73

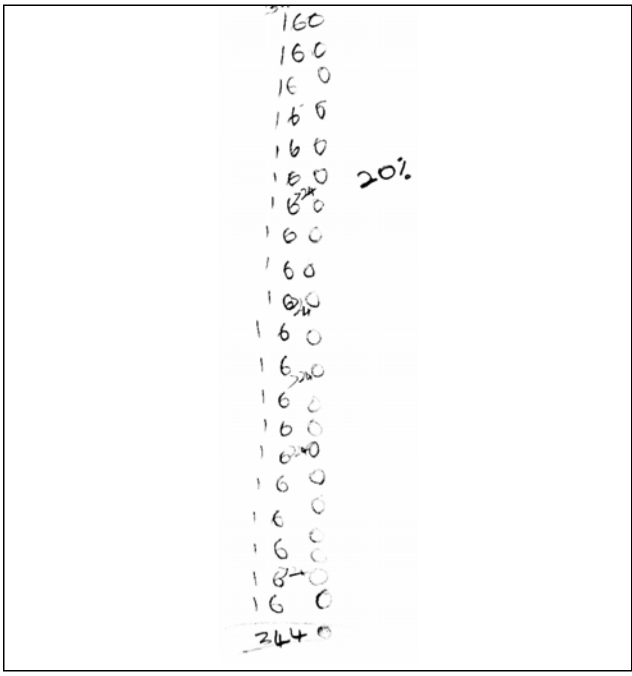
Score: Matched Items: Part Two: 8

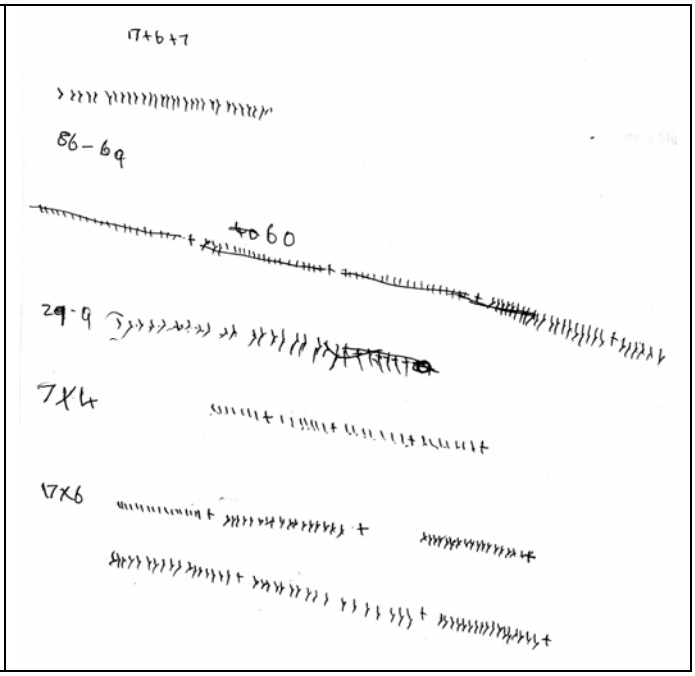
	Question 17 (Add)	Question 18 (Subtract)	Question 19 (Multiply)	Question 20 (Divide)
Scores: Part Two	5	5	5	5

Eric Schollar and Associates

Items in Part One are from the previous version of the National Systemic Evaluation Grade 6 instrument and are used with the kind permission of the National Department of Education.

These examples illustrate the enormous differences in ability in Grade 6 learners. The learner from a control school in the first can barely write and scored zero on the test, the second can write and scored 73 out of 86 (85%). Yet both were passed as competent at the end of Grade 5.





Both examples are from control schools. In the first, the learner attempts to calculate 20% of 160 by using repeated operations while the second illustrates the use of unit counting to solve addition, subtraction and multiplication problems.

APPENDIX TWO

REPORTS FROM SCHOOLS AND EXAMPLES OF TEACHER RESEARCH DIARIES

These scans are of formal school reports submitted to Circuit Managers, as well as extracts from research diaries kept by teachers and provided to ***ESA*** at the end of the field test.

Magangeni Primary School

P O Box 46
Malamulele
0982
Tel/Fax: (015) 851 0133

Ref: Statistics Report **30 August 2007**
Enq: Chabalala M. L

GRADE 6

- Learners have done well in addition, subtraction and division in that diagnostic test, they did and grouped in their right groups (that is Lion work for grade 6).

- With multiplication, 60% were grouped under elephant and goat groups. They still need serious practice in multiplication.

- The research has motivated them to count faster than before. They also found interesting counting using playing cards than counting with their sticks and fingers.

- At the moment, they are doing week 6 (That is multiplication).

GRADE 4

-Did well in addition and division in that diagnostic test. They performed well in their right group(That is elephant work for grade 4

- With subtraction and multiplication 90% were grouped under cow group. Still need serious practice in counting fast, using playing cards.
- Right now they are doing week 3 (that is subtraction)

PRINCIPAL

DEPT. OF EDUCATION
MAGANGENI PRIMARY SCHOOL
30 AUG 2007
P.O. BOX 46 MALAMULELE 0982
TEL: 015 851 0133

Magangeni Primary School strives to provide the learners with basic essentials of life i.e. quality education

ENQ: MATHONSI L. W
CELL: 082 941 7513

MAVAMBE COMBINED SCHOOL

NTWANANO I MATIMBA

BOX 1125
MALAMULELE
0982

MATHEMATICS REPORT

INTRODUCTION

This report is aimed a giving progress and development as far as the Mathematics project is concerned. Progress and development is literally visible.

LEARNER TEACHER SUPPORT MATERIALS

We have been resourced by LTSM, though we still need more.

ABILITY OF LEARNERS

The project have assisted our learners greatly in counting; multiplication tables.
The learners have even gained a lot of confidence.
The learner group titled cows is now called elephant
The elephant group is now titled the gait group.
We have few learners in the Lion group.

GROWTH

The project have assisted our learners in becoming positive about Mathematics
This project has taken our learners to a higher level.

CONCLUSION

The development of the project may need the following

- More LTSM
- More workshops
- More school visits and tests

As prepared

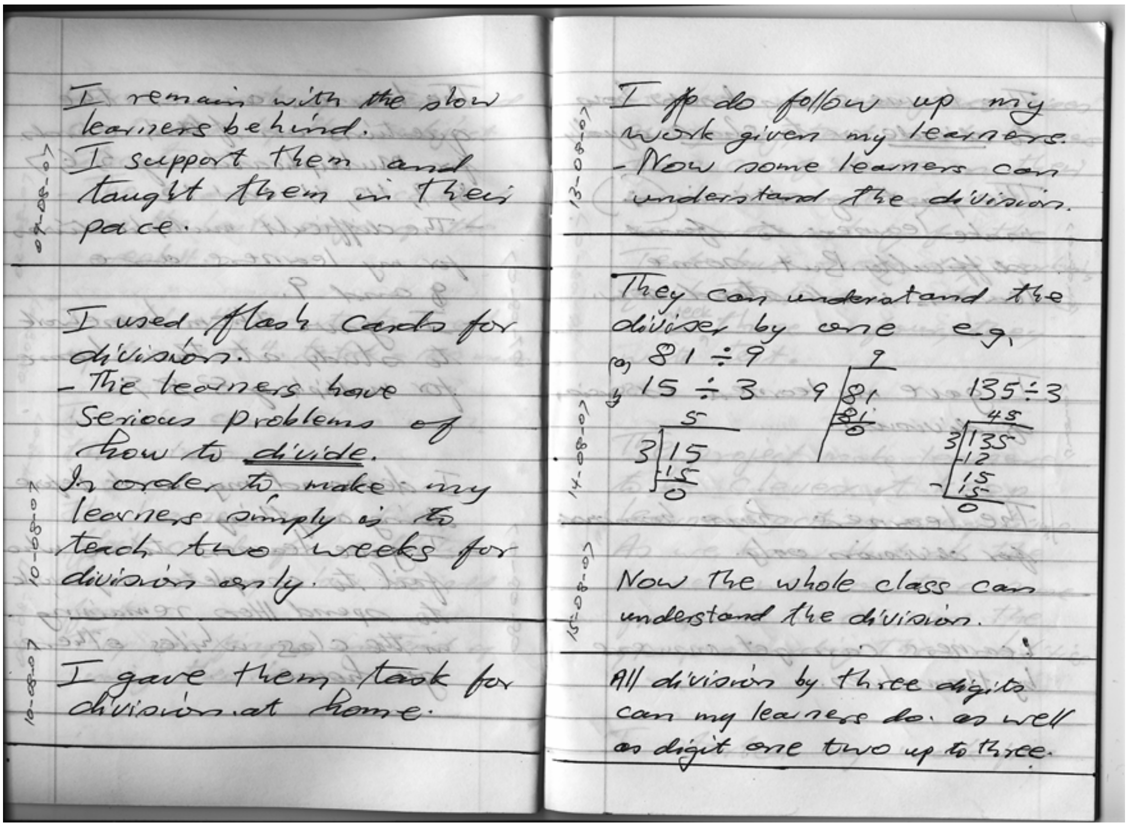
Mabasa H. E.......................................

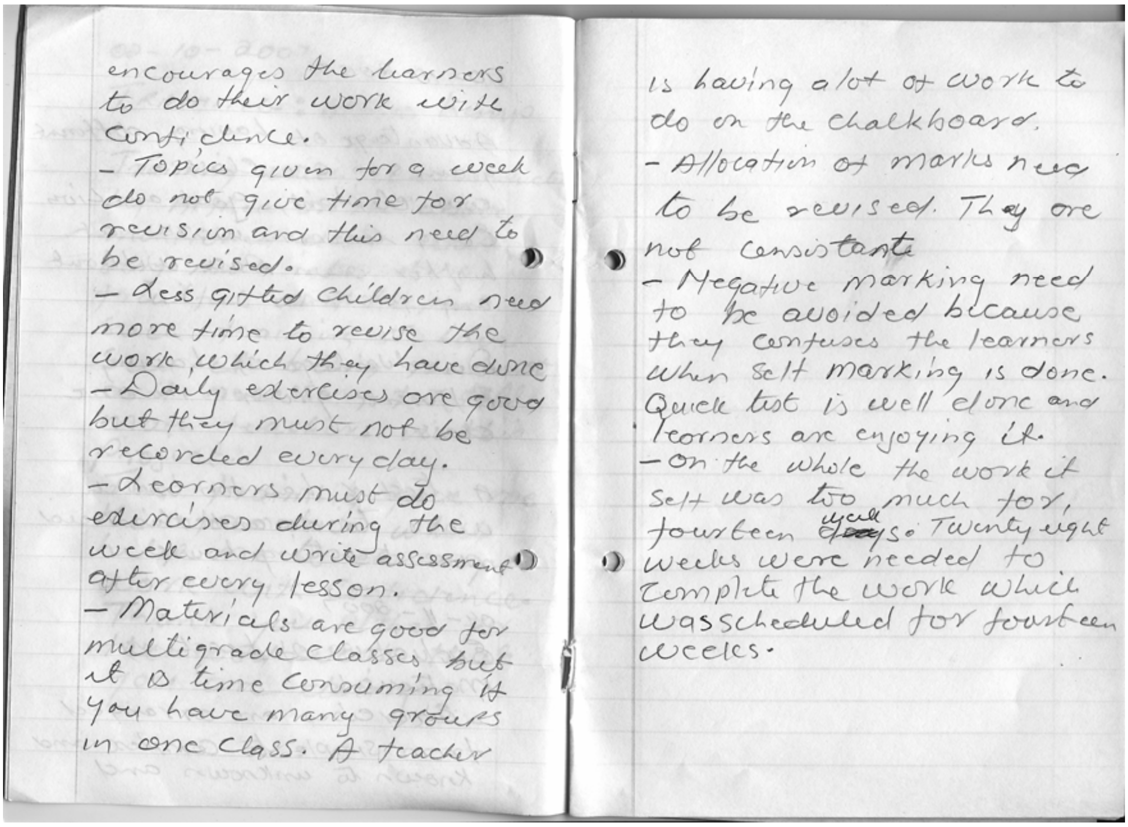
Jeleni G.G.......................................

Approved

Mathonsi L W.......................................

WE AIM TO BREED WELL EDUCATED; EQUIPED AND DEDICATED LEARNERS WHO WILL SERVE THE COMMUNITY AND BECOME USEFUL CITIZENS OF OUR COUNTRY


09-08-07
I remain with the slow learners behind.
I support them and taught them in their pace.
10-08-07
I used flash cards for division.
- The learners have serious problems of how to divide.
In order to make my learners simply is to teach two weeks for division only.
10-08-07
I gave them task for division at home.
13-08-07
I do follow up my work given my learners.
- Now some learners can understand the division.
14-08-07
They can understand the divisor by one e.g.
81 ÷ 9
15 ÷ 3
135 ÷ 3
15-08-07
Now the whole class can understand the division.
All division by three digits can my learners do as well as digit one two up to three.


encourages the learners to do their work with confidence.
- Topics given for a week do not give time for revision and this need to be revised.
- Less gifted children need more time to revise the work, which they have done
- Daily exercises are good but they must not be recorded every day.
- Learners must do exercises during the week and write assessment after every lesson.
- Materials are good for multigrade classes but it is time consuming if you have many groups in one class. A teacher
is having a lot of work to do on the chalkboard.
- Allocation of marks need to be revised. They are not consistant.
- Negative marking need to be avoided because they confuses the learners when self marking is done.
Quick test is well done and learners are enjoying it.
- On the whole the work it self was too much for, fourteen weeks. Twenty eight weeks were needed to complete the work which was scheduled for fourteen weeks.

24-05-2007

Finding from diagnostic test.

Grade 4

- Learners were too slow to finish the test. They took more than two hours to complete the whole work. Most of the learners were using small sticks to do the calculations. The highest mark in this test was 26 and lowest mark was 0. Multiplication table is the problem in this class.
- Grade 6

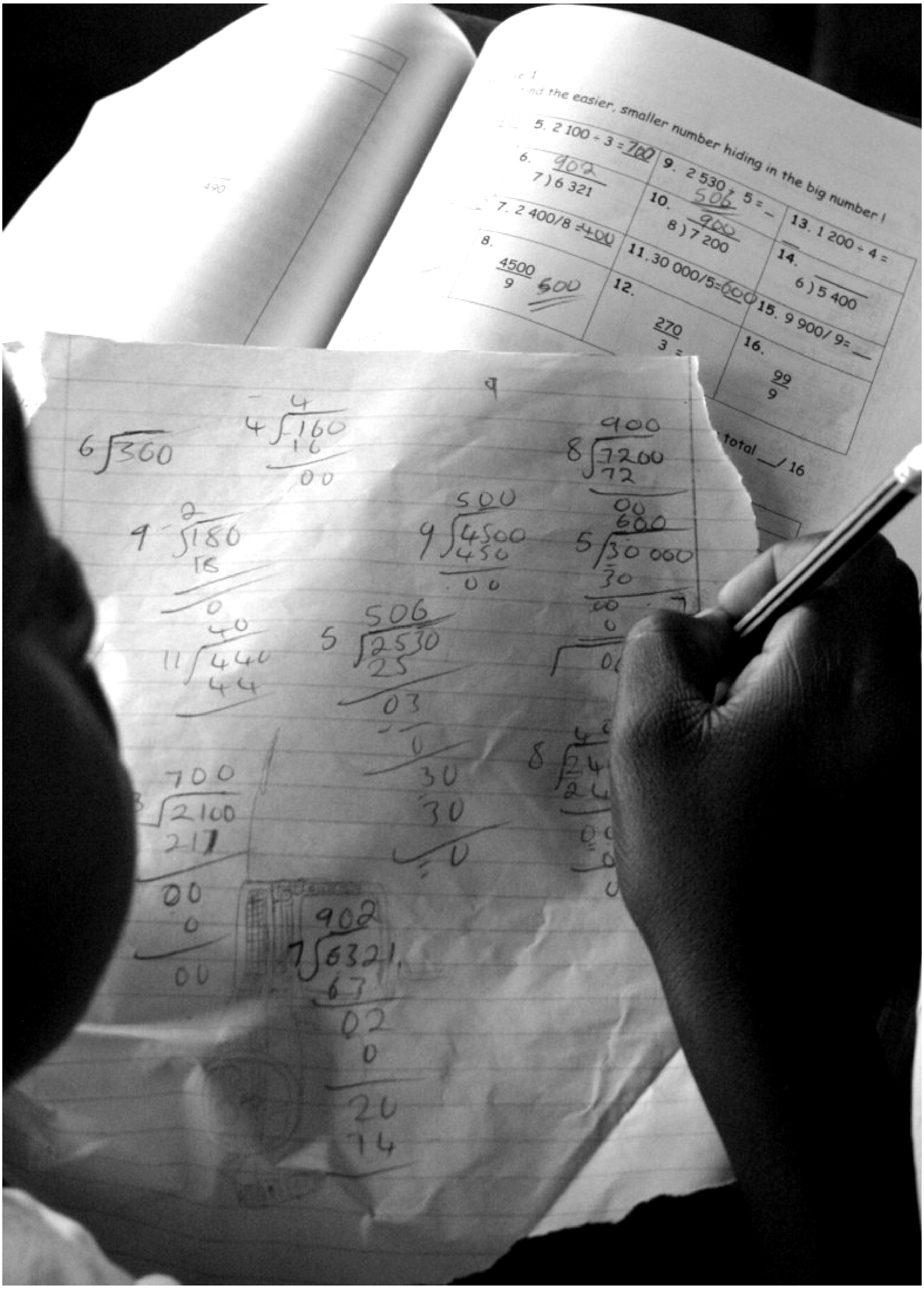
Grade 6 learners like grade 4 learners were also too slow. They also took two hours to complete the whole work.

10-08-07

- The project make learners be happy
- The project make the educator simple to do his work.
- No time waisted because he/she cannot write on the chalkboard because all the excercises are in their learners hand books. and the space of answers are there. He can write one or two examples on the chalkboard and the rest are their in the learner's books
- These project encourage all learners from the slow learner to the fast learners because at the end of the

APPENDIX THREE

PHOTOGRAPHS FROM THE FIELD

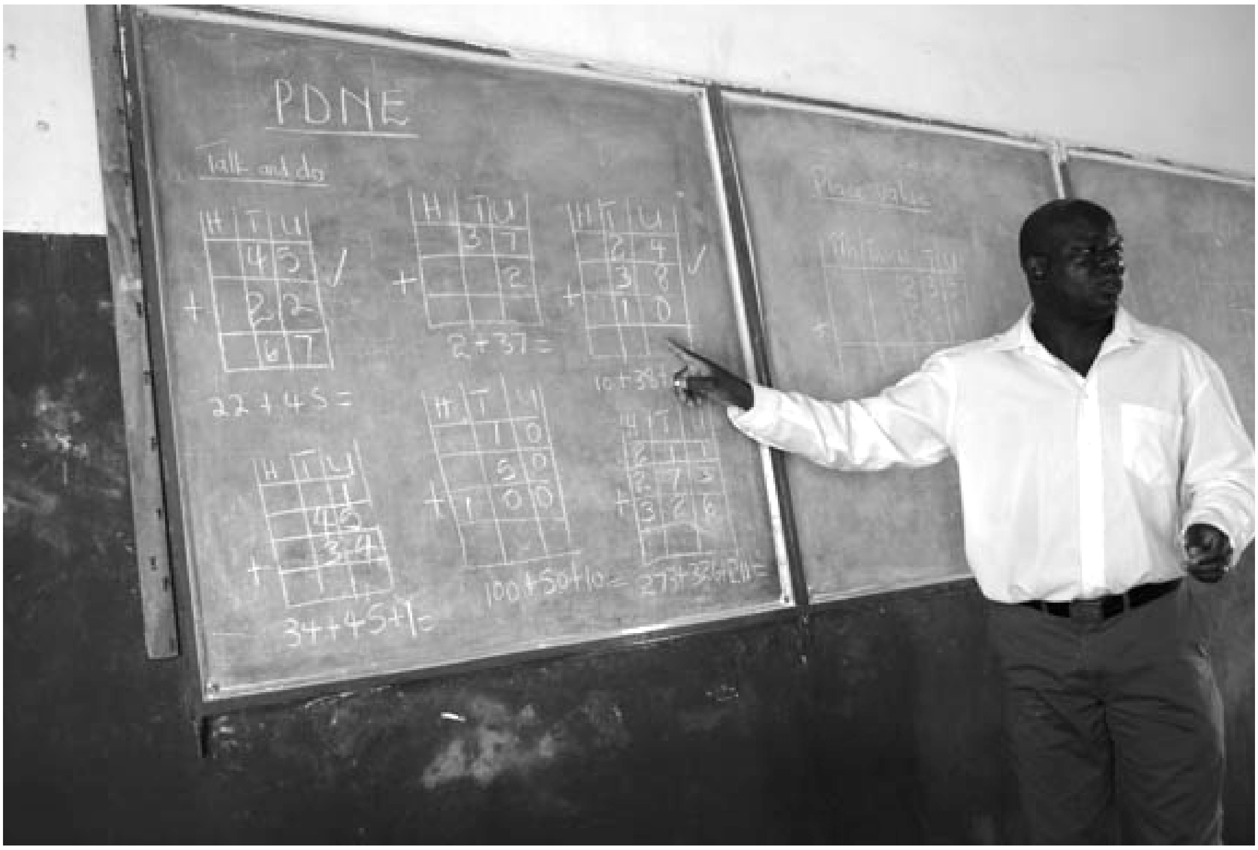


This photograph, taken during the piloting of the materials, illustrates a Grade 4 learner in a project school practicing the solving of division problems using whole number calculations.

Group work: the winner of a flash card (mental arithmetic) game in Grade 4.

Learners working as individuals.

Learners working in pairs.



Direct instruction: the teacher explicates place value during the Listen and Learn Phase of a lesson in Grade 4.