CHAPTER 7

AN ALTERNATIVE APPROACH TO ASSESSMENT FOR THE MATHEMATICS ACCESS MODULE

7.1 The second set of action research cycles

From Chapter 4 it is clear that the introduction of study material and assignments, together with some face-to-face support via contact with lecturers and the provision of tutorial classes, did not bring about the desired levels of success in terms of student retention or pass rate. From discussions with lecturers and tutors who had had contact with students, several problems characteristic of surface processing of study material gradually become evident. There seemed to be limited ability or willingness to navigate through the study guides. Students did not know where in the study guides relevant concepts had been introduced, or how different concepts might be related. Students demonstrated a lack of analytical thinking in the answers to their assignment questions: in many cases answers given in assignments appeared to be unrelated to the problem-solving processes that preceded them. Many students could not identify appropriate mathematical procedures or check that they had applied them correctly. For example, in solving equations using logarithmic laws, they did not necessarily recognise that their 'laws' were incorrect, and did not check how the law was stated in the study guides.

It seemed possible that student learning and poor examination results could be related to the assessment methods that were being used. It was thus decided to investigate the potential of an alternative assessment method for improving the situation. The fact that assignments could from 2001 include LMQs (see Table 4.1, in Chapter 4) made it possible to adapt one of the assignments to address problems such as those mentioned above. The use of an alternative form of formative assessment was also considered as a means of promoting creativity, an aspect of a mathematics curriculum advocated by Usiskin (1999) and English (2002).

This chapter describes three cycles in the second parallel set of action research cycles. These research cycles focused on a particular intervention which was planned, implemented and modified during a three-year period: 2001, 2002 and 2003. The intervention consisted of an alternative assessment tool, namely a project, which replaced one of the standard assignments. Adaptations were made over the years, and results were analysed. The 2001 results led to several modifications; these then led to two further cycles, which took place during 2002 and 2003.

In this chapter we consider briefly assessment policies, practices and guidelines at UNISA, to provide the context for the choice of a project as an alternative assessment tool for Mathematics Access Module students. The rationale for introducing a project is discussed. The chapter deals with the design of the project, consisting of two tasks, namely Task A and Task B. Specific marking criteria were set. Aspects of student performance in the tasks were investigated. During the first action research cycle, performance of students in either Task A or Task B was investigated (since students had the option of choosing only one task). The results led to modifications in the way the project was constructed and used in 2002. Once again aspects of student performance were investigated. In the second research cycle performance of the students in both tasks was investigated. Analysis of the results in 2003 was carried out in a third action research cycle.

The research that took place during these three cycles was to some extent informed by results in the corresponding set of action research cycles relating to reading skills. Phases I, II and III of the reading intervention had increased the awareness of the reading difficulties that students were experiencing. This led to a greater awareness of reading and language problems that were evident during the research. As can be seen from the discussion of the tasks below, correct use of language and terminology was an aspect of Task B; the reading intervention bore out the need to consider more than language proficiency.

Additional findings emerged from the three cycles in the alternative assessment intervention. Apart from reading and language problems, there were a number of other problem areas, such as limited sense of number, weak meta-cognitive skills, the meaning and purpose of estimation, approximation and calculation, and the use of appropriate units. Furthermore, students exhibited a lack of general knowledge, particularly regarding money, the relationship between distance, speed and time, and order of magnitude.

The results emerging from the three cycles are discussed. It seemed that for many students the demands of the alternative assessment project were too high.

7.2 Assessment policy at UNISA

In Chapter 2 we considered briefly some of the purposes and characteristics of assessment. We now consider these in relation to assessment practices at UNISA, to see how it was possible to design a project that would be meaningful for Mathematics Access Module students and meet UNISA assessment criteria.

7.2.1 Types of assessment at UNISA

The UNISA Assessment Policy highlights different types of assessment, reflecting the different purposes for which assessment is undertaken (UNISA, 2003[1]). The Policy makes provision for *formative* assessment, used to improve the quality of students' learning experiences by focusing on relevant knowledge and skills. Both *formative* and *summative* assessment provide accurate estimates of current competence or potential in relation to desired outcomes, thus making it possible for educators to make appropriate decisions with regard to future study or immediate support or advice. *Summative* assessment relates to the stated exit outcomes. Since it is often 'high-stakes' assessment, it is expected to be transparent and defensible. UNISA students should ideally

> receive assessment that will maximise their learning, while also providing them with effective cognitive skills (foundational and reflexive), practical skills and learning attitudes and values they will need in practice after certification. … Student assessment practice is an integral part of curricula and should be consistent with the [curriculum] principles outlined … It should also enhance student progress and ensure the status and value of UNISA qualifications (UNISA, 2003).

The 'curriculum principles' outlined in the document include the following: 'Curricula should acknowledge that teaching is more than a process of transmitting knowledge; it also incorporates the inculcation of an attitude that encourages a critical approach'. The UNISA Assessment Policy takes into account the unique nature of distance learning, and regards assessment as a learning opportunity and not merely a test of learner performance; it emphasises the need to include individual learner support and feedback, especially for students who are unfamiliar with, and often alienated by, the distance learning experience.

For several logistical reasons (availability of venues, invigilation costs, students' work and family commitments) the knowledge base within disciplines has for many years been evaluated mainly by means of examinations, often only at the end of a year or semester. This summative assessment process has however been supported in many cases by a well-developed assignment system, which provides a measure of formative assessment.

7.2.2 UNISA assessment guidelines

The design of all assessment activities is important, whether the assessment is planned for formative purposes (as for example in the UNISA assignment system) or for summative purposes (as for example in the UNISA examination system). In good assessment design, the methods and complexity are appropriate to the stated outcomes and the knowledge base of the discipline. Whatever the purpose, the UNISA Assessment Policy suggests that the following assessment guidelines should be

[1] The UNISA corporate manual on the UNISA website contains all policy documents. The assessment policy referred to here was approved in 2003 but differs very little from the previous policy. It will change slightly to accommodate the policies of the merged institutions.

taken into account (UNISA, 2003): fairness, validity, reliability, practicality, cognitive complexity, transparency, and authenticity. We briefly consider each of these.
Fairness requires that students understand what they are expected to do and what criteria will be used to judge performance (see MSEB, 1993). All standard practices that ensure equal opportunity within the assessment process for all participants should be guaranteed. One way of ensuring fairness is to state the module outcomes and assessment criteria clearly and explicitly. Fairness can for example be ensured by making certain that students know the purpose of the assessment, know what the learning outcomes of the module are, and that they have been able to practise the assessment methods that will be used. In other words, if they are to be assessed using for example group projects, they should be given the opportunity to tackle collaborative projects beforehand (see for example Beevers & Paterson, 2002). Fairness also suggests that different assessment methods should be used.

Whatever assessment tool is used, validity requires that the stated outcomes are assessed in ways appropriate to those outcomes, and in accordance with the stated assessment criteria. Three important forms of validity are *face validity*, i.e. assessment should be perceived to be fair, giving students a reasonable opportunity to show what they know and have mastered; and it should be free of bias; *content validity*, i.e. the assessment should relate to the stated aims of the course, and cover content adequately, focusing on the important outcomes and not on peripheral details; and *construct validity*, i.e. the assessment should test what it claims to test.

Reliability can be achieved by ensuring that the assessment tools used can produce the same results when similar learners are tested again on the same test in a similar context. Reliable assessment is based on objective judgements, so that issues such as different markers rating students differently are ruled out.

Practicality requires that assessment procedures should not be too difficult or too expensive to implement. At tertiary level assessment tasks should exhibit appropriate cognitive complexity to assess higher levels of thinking. Assessment can be considered transparent when students know what is expected of them, implying that assessment criteria and policies are clearly communicated and adhered to. Authenticity suggests that assessment should in some way be directly related to real-life use of the knowledge and skills learnt, i.e. outside educational settings. OBE too requires assessment to be relevant. As has been pointed out, OBE also challenges educators to consider innovative forms of assessment.

7.3 Rationale for the introduction of an alternative form of assessment

Apart from high attrition rates[2] and relatively low pass rates[3], lecturers and tutors were concerned that many students were finding it difficult to relate mathematical concepts to everyday issues, even though the study guides provided relevant examples. Also, students were unable to explain why they had followed a particular procedure, how they had made deductions, and where they could find information in their study guides. The tendency to interpret mathematics as the application of routine procedures, relying primarily on rote methods of learning, was clearly prevalent.

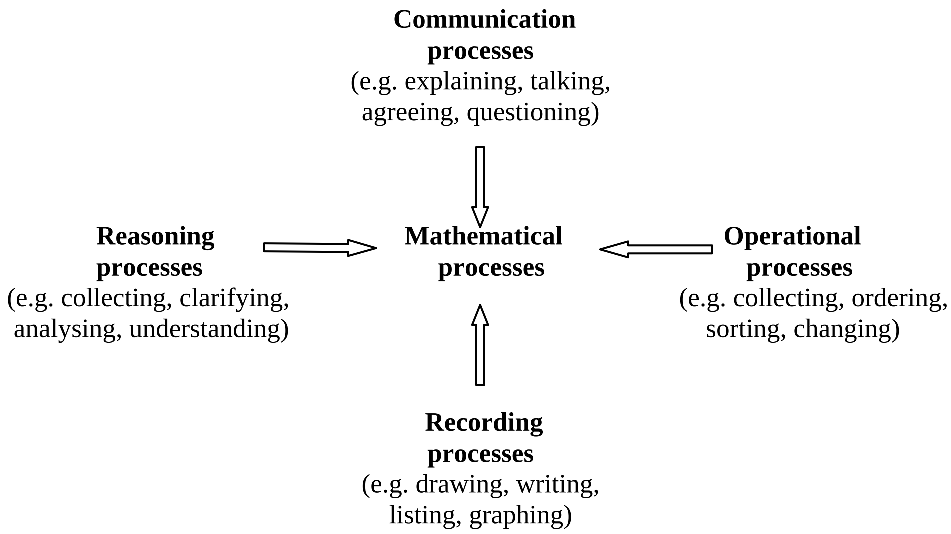
In 2001 it was thus decided that assessment for the Access Module should to a greater degree reflect real-life contexts; that students should be given an opportunity to demonstrate that they had grasped important basic concepts well enough to apply them and to recognise errors; that students should show that they could 'find their way' around the study material. To this end a project assignment was designed, incorporating these skills. It was felt that project work might have a positive impact on learning, since it could reflect the learning outcomes of the module, and also offer a form of assessment different from the types of tasks students were used to doing. A project might also facilitate deeper learning by providing greater opportunity for application, and relying less on recall. It might have the potential to engage students in critical and creative thinking, and be more stimulating, by relating to real-life contexts of the students' choice. A project could help to build student confidence in using mathematics in a variety of contexts, and possibly enable them to become more mathematically literate, i.e. better able to understand and interpret material with a mathematical flavour in magazines, newspapers, or on the television.

Mathematics learning and assessment involves a number of inter-related activities. In any problem-solving task, or investigation, there are a number of mathematical processes that need to take place, sometimes simultaneously, as illustrated in Figure 7.1 (Frobisher, 1994).

[2] See Table 8.4 in Chapter 8.
[3] See Table 8.9 in Chapter 8.

Figure 7.1:

Mathematical processes



In the project, students would be able to engage in these processes, and become aware of the importance of, and the difficulties inherent in, understanding, explaining, writing, collecting, etc. While it is not clear from the article in which this diagram appears why ‘collecting’ should be classified as a reasoning process, the article and diagram are useful in that they emphasise that problem solving (one of the module outcomes) is dependent on the assimilation of such processes, so that practice in using them is likely to be advantageous.

The idea of using a project seemed to be in line with similar initiatives elsewhere such as the ‘Realistic Mathematics Education’ (RME) movement in The Netherlands (van den Heuvel-Panhuizen, 1996). The major tenets of RME arise from the thinking of Hans Freudenthal, who stated that ‘What humans have to learn is not mathematics as a closed system, but rather as an activity, the process of mathematizing reality …’ (Freudenthal, 1968; in van den Heuvel-Panhuizen, 1996, p. 10).

It is apparent that many students can learn mathematics for several years and yet be unable to use this mathematics outside the learning context (Boaler, 1998). An example of this was evident in the investigation into student reading speed, carried out in 2003: when asked to calculate their reading time, which necessitated finding the difference between the starting time and the finishing time, several students added the two times.

Clark & Jasper (1995, in Clements & Ellerton, 1996) promoted the use of a range of assessment strategies, including activities such as ‘student-constructed test items’ and ‘student investigative projects’, as a means of effective mathematics teaching (p. 157). Assessment tasks that resemble learning tasks were also seen to provide an opportunity for constructing mathematical knowledge, by promoting strategies such as ‘analyzing data, drawing contrasts, and making connections’ (MSEB, 1993, p. 71). Rowntree (1997) suggested that projects encouraged students to draw on resources other than those included in the course, helped them to relate the course objectives to their own interests and individual contexts, facilitate development of higher order thinking skills, and led to their development as autonomous students.

The Center for Research, Evaluation, and Student Testing (CRESST)[4] at the University of Los Angeles created a task force to investigate the equity challenges inherent in assessment (MSEB, 1993). It is clear that the context in which mathematical tasks are presented can influence performance. Better readers may grasp more easily what assessment tasks require. Open-ended assessment procedures may exacerbate the influence of resource inequities, and subjective decisions on the part of the marker may play a role here as well. CRESST proposed an assessment blueprint, and recommends that the following aspects are taken into account with respect to assessment.

World knowledge needs to be taken into account. What common experiences do students need in order to make sense of a task and find a solution? Which of these are more or less likely for students of different cultural and socio-economic backgrounds? Also, *prior knowledge* must be considered. What specific types of information (as well as knowledge) are prerequisites for successful performance? The *language demands* of assessment tasks play a role. In mathematics the focus of the study material and the students is unlikely to be facility with the language of instruction. In what alternative ways can students who are not proficient in English display understanding? It is important that the *task structure and topic* be accessible to all. Is there sufficient diversity in the topics selected for assessment or study purposes, to ensure that all students will find tasks stimulating and will be motivated? As far as the *scoring criteria* are concerned, are criteria specific enough to ensure objectivity? How are the *judges* selected (in a South African context the word ‘examiners’ or ‘markers’ would normally be used)? Are they mathematically sufficiently competent in the domain being assessed? Is there potential for bias (gender, ethnicity)? Have the judges been trained? Has *access* been taken into account? Who is excluded from assessment, and why? Are alternative arrangements possible for students with special needs? Has any consideration been given to *the equity of educational assessment settings*? What is the quality of the educational experience to which students have been exposed, prior to assessment?

[4] This acronym appears to have an extra ‘S’, but is given as it appears in the text.

For the Mathematics Access Module, the introduction of the project and the analysis of students' performance in the different tasks formed the second set of action research cycles. It took place alongside a parallel set of interventions relating to reading skills, but was conceptualised first (in the middle of 2000) and implemented for the first time in 2001. We now consider the design and introduction of the project, and the results that were obtained.

7.4 Methodology for this intervention

This section describes the design of the project, the modifications that were made over the three years during which the project was implemented, and the different evaluation procedures that were undertaken during the three action research cycles associated with this intervention.

7.4.1 Design of the project

The project consisted of two different tasks. One task involved using or creating a real-life example in which specific mathematical concepts could be applied; the other involved students in assessing the work of a hypothetical student. Giving students the opportunity of evaluating one another's work according to a specified set of criteria appeared to be beneficial in the Science Foundation Programme at the University of Natal, Pietermaritzburg. This form of assessment was successful in deepening students' conceptual understanding and enhancing meta-cognitive development (McKenzie, Grussendorf & Grayson, 1996). One aspect of the University of Natal study that emerged was the need to keep the assessment tasks simple, as it was possible that the skills required to understand and apply marking criteria to more difficult tasks were not as well developed as necessary.

The envisaged project seemed to meet SAQA/OBE requirements in terms of providing some (albeit small) opportunity for meaningful formative assessment that was valid, fair, reliable and practical. The project was designed with a number of requirements in mind. Students would learn and apply what they had learnt in an authentic context, since it is true that 'Students learn important mathematics when they are using it in relevant contexts that require them to apply what they know and to extend how they think' (MSEB, 1993, p. 20). Students would know what was expected of them, and recognise whether or not they had met the expectations. The project was criterion referenced (see Spady, 1994: in a criterion referenced system, clearly defined criteria are the basis for organising actions and for making decisions). Clear criteria were set out for both tasks, and students could check whether or not the criteria had been met, so that they could gauge their success in terms of meeting the specified criteria. Criterion-referenced assessment tends to be more formative than norm-referenced assessment, in that it identifies what a student has achieved against what should have been achieved (Beevers & Paterson, 2002). Group work could be promoted through the use of a project. Mason

(2002) points out the benefits of groups of students working together to grapple with particular mathematical problems. Many of the general, specific and cross-field SAQA outcomes (see Appendix C) could also be satisfied in a project.

The two different types of tasks that were set were classified as Task A and Task B. In 2001 students could choose to do either Task A or B, and work in pairs if they chose to do Task B. In 2002 and 2003 the assignment required that they do both tasks. (See Figure 3.2.in Chapter 3.) The two tasks were both based on Books 2 and 3 only (basic numeracy and simple algebra). The tasks were as follows:

Task A[5]: A mock assignment was set, and a fictitious student's answers were provided. (From now on for convenience this fictitious student will be referred to as FS.) Students were required to mark (in the sense of pointing out errors and making comments, but not writing out correct answers) the assignment, providing clear comments on mistakes that had been made, and referring FS to sections in the guide where he/she could find information regarding concepts that had been misunderstood.

Task B: Students could create an 'application' similar to those provided in the Access Module study guides (exercises showing how the mathematics learnt applied to real life situations such as monthly expenses, or HIV/AIDS trends), either based on a fictitious situation or based on an event or situation with which they were familiar (e.g. something obtained from a newspaper, or a magazine article). The purpose of this task was for students to integrate and contextualise their knowledge. They were required to create a meaningful set of questions that covered specified content, and to provide clear solutions to these questions. The content areas specified were ratio, proportion, estimation, comparison of fractions, and conversion of units of measure (such as units for currency, time, mass, distance).

The rationale for both types of task still appears to be valid. Mason (2002) suggests that although students need to see what 'good', complete solutions should look like, it may be even more helpful for them to see a less-than-perfect script, with the lecturer's comments showing how it could be improved. In the examples and activities used to illustrate different topics in the study guides, students would have seen 'perfect' solutions to problems. In the solutions they received for Task A they were shown an incorrect script and how it should have been marked. Appendix G contains a sample section from Task A, and the corresponding sections from the solutions. Mason (2002) points out that providing a hypothetical argument, which is corrected several times (in this case by the student first, and then by the lecturer, as presented in the assignment solutions) helps students to see the contrast

[5]The assignment for 2001 and 2003 was given in Tutorial Letter 101 for the Access Module. For 2002 the

between what they may be providing and what is actually expected from them. Mason also suggests that student understanding of a mathematical concept can be effectively assessed by having them construct examples in which the concept is applicable, as they were required to do in Task B. Boaler (2002) refers to the benefits of situated learning, where students are given the opportunity of interacting with mathematics in different forms and settings.

7.4.2 Marking criteria

Each task needed to be individually assessed. In order to mark the different tasks, external funding[6] was used to appoint a marker experienced in dealing with students at this level, with insight into their problems, and with sound mathematical knowledge and appropriate teaching experience, particularly in the assessment of portfolio work. With 1 279 registered students in 2001 it was anticipated that about half that number would undertake the project. Even so, it would not have been possible to tackle a project of this scope without additional marking assistance.

For Task A, for each student the following aspects were recorded: the number of errors in FS's assignments that they had noted; the extent to which they could explain why FS's solution was incorrect; the extent to which they could provide study guide references for the mistakes noted. Students could indicate mistakes in various ways, for example with a cross, by circling or underlining, or by writing a brief comment. The number of mistakes was denoted by M. The mistakes made by FS comprised calculation errors, mathematically unacceptable presentation, use of inappropriate or incorrect symbols, confusion with units, logical and conceptual errors, and incomplete solutions.

The mistakes required various different explanations, from very simple statements such as

> You haven't checked to see whether both solutions are valid.

to more complicated ones such as

> It isn't logical that Jan takes <u>less</u> time when he works on his own than the time taken when he and Tumelo work together.

The explanations were marked according accuracy, clarity, and correct use of mathematical terminology and notation. The number of explanations was denoted by E.

The errors required students to identify a number of references in the study guides on which the assignment was based (Books 2 and 3). These were marked according to whether the reference was

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assignment appeared in Tutorial Letter 103. The solutions appeared in Tutorial Letter 203.

[6]Funding was available from the South African Science Education Network (SASEN), a brief association (from 2000 to 2002) involving UNISA, the University of Pretoria, the University of the Western Cape and Vista University (Bloemfontein), funded by the Belgian Government and the University of Louvain.

clear and appropriate. The number of references was denoted by R.

The M score was converted to a total out of 15, the E score was converted to a total out of 20, and the R score was converted to a total out of 15, giving a maximum score of 50 for this task. The total for the task was denoted by T.

In the marking for Task B, students were assessed in terms of five different criteria, namely the extent to which they had covered the required content; the extent to which the questions they set tested understanding of the required concepts; the coherence of the questions they set, i.e. the extent to which the questions related to the selected topic; the clarity of the solutions they provided; and the correct use of mathematical notation and terminology.

In 2001, 15 marks were awarded for each of these categories, giving a total of 75 marks for this task. The total was converted to a percentage. In 2002 and 2003 the system was adapted, and marks were allocated as follows: content: 12; understanding: 12; coherence: 20; clarity: 3; language/terminology: 3. Clarity of explanations and the acceptable use of terminology were found to overlap to a large extent in 2001, and it was thus not helpful to allocate 12 marks in each of these categories. Doing so gave these factors greater importance than understanding or coherence, which was not the intention. Furthermore, clarity of explanation and terminology were also targeted in Task A.

Marked assignments (containing the marker’s comments and suggestions) were returned to students. All students also received a tutorial letter containing detailed explanations of all mistakes and all necessary references, as well as an example of how a lecturer would ideally have marked the assignment. No generalised comment was possible for Task B.

7.4.3 Aspects of student performance investigated

For each of the three years the project assignment results were compared with the examination results. Only the year-end results were considered, i.e. additional passes based on the supplementary examination[7] results were not taken into account. The purpose of the investigation was to compare performance in the project with examination performance. Since the examination did not contain tasks such as those in the project, it seemed unlikely that students would study for the examinations from the printed solutions for the project or other project feedback they had received. It was thus unlikely that the project would have contributed anything further after the October/November examination had been written.

[7] Entry to the supplementary examinations is discussed in Chapter 8 (see 8.2.3).

As was noted in Chapter 5, examination results in 2001 might have been affected by Phase II of the reading intervention, but the small number of students involved rule out any significant impact. Students in 2001 were thus on the whole exposed to only one intervention, namely the alternative assessment project. In 2002 and 2003 students were exposed to two simultaneous interventions. This would have had some impact on their overall performance, but no attempt was made to investigate the impact of the project in isolation from the reading interventions.

Task A

Each of the M[8] and T scores (both converted to percentages) was compared with the examination score (denoted by P). Since not all students achieved examination admission (or, if they did, decided not to write), it was only possible to consider those students who wrote the examination, and disregard the rest.

Task B

Too few students did Task B in 2001 for meaningful comparisons to be made with examination marks. The project was thus modified in the second and third action research cycles, so that students were required to do both tasks in 2002 and 2003. Students' selection of content, understanding of concepts and the coherence of the concepts were regarded as more important than other aspects, and were allowed to contribute most to the total for Task B in 2002. It was, however, decided not to compare individual components of Task B against the examination mark, and to compare only the total mark for the task (converted to a percentage, and denoted by B) with the final result. Apart from the increased time involved in data capture, coherence usually implied that the required content was covered (the converse was not true: very often the required content was covered using separate scenarios, so that there was no coherence); clarity of solution and correct language and terminology (notation) would already have been evident to some extent in Task A, as noted above.

It was later decided that Task B would not be taken into account for credit purposes (this is further discussed below, and in Chapter 8). It was however marked, albeit superficially in some cases. Where a student had done Task B only, or had put considerable effort into the task, it was marked in detail, and either the average for the two tasks or the Task B mark was allocated for the assignment.

7.4.4 Overview of project

For reference, Table 7.1 gives an overview of the way the project was used.

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[8] Since the E and R scores were dependent on the M score, there was little to be gained by comparing the E and

Table 7.1:

Overview of the project

Year	Tasks required	Tasks used for credit purposes	Weight of tasks	Task A: Number of errors (M)	Task A: Number of explanations (E)	Task A: Number of references (R)
2001	A or B	A or B	A: 50% B: 50%	35	40	35
2002	A and B	A	100%	22	23	26
2003	A and B	A	100%	24	24	24

7.5 Results obtained

In the discussion of the results, various examples of students' work are quoted. Sections of students' assignments were photocopied. Examples were transposed and collated according to different categories. (See 7.6.) Examples from Task A are indicated by the numbers A1, A2, etc., and examples from Task B by B1, B2, etc. All quotes are given verbatim.

7.5.1 The 2001 results

In Task A in 2001 there were 35 mistakes students should have noted, resulting in 40 explanations and 35 references.

A total of 861 students attempted the assignment, more than the anticipated number. The overall impression from discussions with some students indicated that students enjoyed the assignment, although they said they found it difficult. The following comment from one of the students, who only did Task A (A104), was interesting:

> *This assignment helped me to understand how much time do I put on my studies and I put less time, but I fairly knew and have gone through most of the Sections before. I don=t think I=ve done well as I should have, because truly speaking the assignment was very easy. If I do badly it means I should start "pulling my sox".*

Many more students attempted Task A than Task B, possibly thinking it was easier (only 59 students attempted Task B). The spread of marks for Task B was far wider than for Task A: the highest mark for Task A was 68% with only two other students obtaining over 50%; for Task B the highest mark was 97%, with many marks over 50%, as Table 7.2 shows.

R scores with the exam result. Hence only the M and T scores were taken into account.

Table 7.2:

Overview of marks achieved in project assignment in 2001

Task	Number of students	Mean mark (%)	Median mark (%)	Mode (%)	Minimum mark (%)	Maximum mark (%)
A	802	16,3	14	8	0	68
B	59	47,4	45	75	0	97

In general students performed poorly. Through interaction with a limited number of students (either when they phoned to discuss a problem, or when they had contact sessions with lecturers, and were asked about their perceptions of the assignment) it seemed that 'good' students were scoring between 40% and 50% for Task A, with most students scoring below 20% (the mode was 8%). The only students who obtained marks over 70% did so in Task B. It was initially assumed that the 'better' students possibly tackled Task B, and did better – either because they were academically more mature, or because it was actually easier; these students may also have had easier access to suitable data, and possibly enjoyed the challenge of doing something original. However, this perception was created by good marks obtained in a few cases (nine students scored over 90%) and it was not verified in the examination results, as can be seen from Table 7.3.

Table 7.3

Examination results of students in relation to performance in Tasks A and B

	Task A	Task B
Number who wrote examination	502	43
Number who passed	97	7
Percentage of passed/wrote	19,3	16,3

Of the 59 students who did Task B, six did not obtain exam admission. Of the 53 students who qualified to write the examination, 10 were absent. The ratio of the number of students who passed (seven) to the number who wrote (43) is approximately 16,3%. The corresponding figure for those who did Task A is 19,3%. In other words, the examination performance of students who did Task B was not better than that of the students who tackled Task A.

Comments regarding Task A

In their approach to Task A, in some cases students seemed to be at a loss as to what to say. For example (A31):

> *You didn't do mistake. Nothing is wrong. The answers are correct.*

In general students noticed errors in calculation, but did not notice conceptual errors, such as incorrect application of logarithmic laws or incorrect solutions of inequalities.
They also mostly ignored notation and presentation errors, even though these often resulted in illogical
or incomprehensible statements. Consider the following example (A106). The question dealt with the comparison of fractions by means of conversion to percentages.

FS's solution was given as:	Student's comment:
Sarah: $\frac{16}{25} = \frac{16}{25} \times 100 = 64$	*Nice*
Pete: $\frac{36}{45} = \frac{36}{45} \times 100 = 80$	

i.e. the student had no idea that the percentage symbol had been omitted, and that a statement such as

$$\frac{16}{25} = \frac{16}{25} \times 100$$

is incorrect.

On the whole the explanations given by students reflected a number of problems. Although they recognised the errors, they were often unable to express what was wrong. In many cases the explanations were often incomprehensible. Furthermore, explanations were often totally wrong, either mathematically (i.e. incorrect notation or symbols used), or with respect to terminology (e.g. using inverse *proportion* instead of inverse *fraction*, for example, suggesting that to divide by ¾ it would be necessary to multiply by the 'inverse proportion' of ¾). In many cases it seemed that students either could not find the relevant references, or did not try to do so.

Comments regarding Task B

In Task B, examples included several interesting studies, in which fairly creative questions were asked and in most cases supplied with correct answers. There were also easier, less innovative, but well-tackled examples. Examples made use of the following scenarios.

Students in 'digs', using fictitious data (B1)
Children admitted to a South African hospital (B2)
The incidence of malaria in three provinces in South Africa, using Department of Health data (B3)
A game farm in KwaZulu-Natal, using fictitious data (B4)
Problems with funds donated for AIDS, based on a newspaper report (B5)

UNISA acquiring a university in the United States of America (fictitious data) (B6)

Correlation of the examination marks with Task A

[Note: It is once again recognised that all scores may have been affected in some by the parallel set of reading skill interventions.]

Table 7.4 shows the relationship between M (mistakes noticed) and P (examination score), and between T (Task A total) and P (examination score).

Table 7.4:

Pearson correlation coefficients *r* between M and P, and between T and P

	P score (%)	**M score (%)**	**T score (%)**
P score (%) (exam)	-	0,40135 < 0,0001*	0,40050 < 0,0001*
M score (%) (mistakes noted)	0,40135 < 0,0001*	-	0,87845 < 0,0001*
T score (%) (Task score)	0,40050 < 0,0001*	0,87845 < 0,0001*	-

*Correlations are highly significant, to be expected from the large number of observations (*n* = 502). (Although 802 students submitted Task A they did not all obtain examination admission or write the examination, as explained in Chapter 8.)

The correlations between M and P and between T and P were both approximately 0,40. From a statistical viewpoint the correlations were moderate; however, considering the large number of factors involved (intangible variables that could not be taken into account or measured, and some of the problems listed below) this value may have some significance. From the calculation of r^2 ($0,40135^2$ and $0,40050^2$ are both approximately equal to 0,16) we see that roughly 16% of the variance in the final examination performance could be related to the error score, and to the assignment total. These figures suggest that although the relationship between these variables is somewhat linear many other factors would need to be addressed if such a task were to be considered as a predictor of examination performance.

Problems that arose

The project did not fulfil all the requirements. It was not practical that one person should mark such a large number of assignments[9]. The marking load was almost unmanageable. Marking the project in 2001 was extremely labour intensive, and the project thus did not seem to meet the requirement of

[9] In spite of the load the marker was willing to undertake the responsibility again in the following year, on the understanding that the number and extent of the questions would be reduced.

being a practical way of assessing students. Neither was it cost effective, given that the fees paid to the marker did not seem to translate into greater benefit to students. Students interpreted the instruction 'mark the assignment', meaning 'point out where there are mistakes' as 'write out the correct answer'. Even though it was stated that they should not merely write out the correct answer, many of them did only that, without identifying the actual mistake in FS's answer. Student performance was generally too low for this assignment to have had any positive effect on the final mark[10]; it was thus not used for that purpose. Finally, students did not check that they had satisfied all the given criteria.

Possible reasons for the problems experienced by the students

The marking instructions were possibly not specific enough, and students may have misinterpreted them. Students seemed to have had very little personal experience of having their own work marked in the way required by the task, so were unsure about what to do.

The marking criteria contained a serious flaw in that losing marks became cumulative: students were asked to find mistakes, comment on them and then provide references; if they did not notice mistakes they did not explain the mistakes and hence did not refer FS to the relevant sections of the study guides. In other words, losing marks in one category inevitably led to losing marks in the other categories as well. This could also explain some of the disparity in performance between the students who attempted Task A and those who attempted Task B. All the answers given by FS were either totally or partially wrong, yet many students did not notice the mistakes. The errors deliberately included in the questions were possibly too firmly embedded in the body of misconceptions that students had not yet 'unlearned'. Also, the study guides offer no 'practice opportunities' that could have prepared students to tackle either of the two tasks. If this had been the case, students may have understood better what was required. This may have been particularly relevant for Task B, where students simply could not imagine what was required.

Modifications made after the first action research cycle

As a result of the problems discussed above, and other factors, several changes were made with respect to the way the project was implemented in 2002 and 2003. Students were not given the option to work in pairs (it appeared that no one had elected to do this in 2001). Students were required to do both Tasks A and B to eliminate any disparity in marks arising from different groups of students being assessed in different ways. To ensure a more acceptable marking load the number of concepts covered in Task A was reduced; the number of questions required in Task B was also reduced, and the marking criteria changed. Task A contained more explicit instructions as well as examples of what was

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[10] In 2001, 2002 and 2003 the final mark incorporated a year mark component. This is discussed in Chapter 8.

expected. An example illustrating what was expected in Task B was also given.

7.5.2 The 2002 results

In Task A there were 22 mistakes students should have noted, resulting in 23 explanations and 26 references. Students had been told that *all* questions contained mistakes, so in this case there was no reason not to comment on each question, or at least refer to the relevant sections of the study guides, even if they could not identify the mistakes. A total of 894 students attempted the assignment. Their results are summarised in Table 7.5.

Table 7.5:

Overview of marks achieved in project assignment, 2002

Task	Number of students	Mean mark (%)	Median mark (%)	Mode[11] (%)	Minimum mark (%)	Maximum mark (%)
A	894	34,7	34	32	0	96
B	894	39,5	32	40	0	100

Comments regarding Task A

Performance in Task A was better than in 2001. The mode for the task was 32%. Students demonstrated that they had understood more clearly what 'marking' an assignment implied; they noticed more of the mistakes relating to terminology and notation; they were also more specific in their explanations and in providing references.

Comments regarding Task B

There was considerable variance in Task B, more so than in Task A. The calibre of the 'good' Task B answers suggested that these students had greater insight into and understanding of the concepts they were dealing with, and these students may have been expected to do well in the examinations. This was not the case, as can be seen from the examination marks indicated in the examples below, and from the correlations in Table 7.6.

Examples show how students used many different contexts on which to base their problems.
One student used a newspaper article entitled 'Eskom Amendment of Prices' (B23). It contained interesting data, with questions not all entirely appropriate, but clearly and correctly answered. This student passed with 53%. Another student wrote an imaginative, tongue-in-cheek 'story' about

[11] For Task B the true mode was 0 (149 students). In the data capture process 0 was awarded to students who legitimately scored zero, as well as to those who did not attempt the task. This has to some extent skewed the results.

Spiderman in New York (B24) with mostly appropriate questions. His solutions were not always correct, and he obtained 20% in the examination. There was an interesting example (B25) about a Mr Sithole choosing between milk and an energy drink instead of having his usual breakfast. The questions were appropriate and correct, but this assignment was unique in the time the student had taken to sketch (very well) both the bottle of milk and the can of energy drink (he obtained 67% in the examination). Another interesting example featured an article (B28) taken from the 26 February 1996 edition of The Wall Street Journal, entitled ‘Project Management in Practice’, dealing with the task of getting the Olympic torch to Sydney, based on the Atlanta Olympic Torch Relay experiences; simple questions were asked, and the data was correctly used in answering them (the student obtained 30% in the November examination, and did not write the supplementary examination). A student used a magazine article (Country Life, April, 2002) (B29) in which the questions were good but the answers less so (the student obtained 39% in the November examination, and did not write the supplementary examination). Another student provided a set of questions based on an article promoting Rennies Thomas Cook Mastercard Travellers Cheques (B30), but he had no grasp of the implications of the article and no understanding of real-life situations involving such matters (see 7.6 below). (He obtained 6% in the examination.)

Correlation of the examination mark against Task A and Task B

Table 7.6 shows the correlations between M (mistakes noticed) and P (examination score); A (Task A total) and P (examination score); B (Task B total) and P (examination score); and A and B. Although 894 students attempted the assignment, only 787 wrote the examination, and the comparisons of the other variables with P were thus based on the lower number.

Table 7.6:

Pearson correlation coefficients *r* between M and P; A and P; B and P; A and B

	P score (%)	**M score (%)**	**A score (%)**	**B score (%)**
P score (%) (examination)	-	0,37780 < 0,0001*	0,36318 < 0,0001*	0,0,33386 < 0,0001*
M score (%) (mistakes noted)	0,37780 < 0,0001*	-	0,86436 < 0,0001*	0,33749 < 0,0001*
A score (%) (Task A)	0,36318 < 0,0001*	0,86436 < 0,0001	-	0,37439 < 0,0001
B score (%) (Task B)	0,33386 < 0,0001*	0,33749 < 0,0001*	0,37439 < 0,0001*	-

*Correlations are highly significant.

The correlations between M and P, A and P, and B and P were all weaker than in 2001 (approximately 0,38, 0,36 and 0,33, respectively). There was a relatively weak correlation between A and B as well (approximately 0,37). (See the discussion below on some of the problems that arose. Several of these problems may have resulted in a student obtaining a high score in Task B and a low score in Task A.)

These results suggest that the assignment as it was used in 2002 bore less relationship to examination performance than in 2001. From the calculations of r^2 it appeared that only 13% and 11%, respectively, of the variance in examination performance could be related to performance in these tasks (for A and P r^2 was approximately 0,13; for B and P r^2 was approximately 0,11).

Problems that arose

A number of different problems arose during the second attempt at using a project assignment. Firstly, although the content of the tasks was somewhat reduced, the project still did not seem to meet the requirement of being a practical and cost-effective way of assessing students, as it was still extremely labour intensive, and seemed to have yielded little benefit to students. The marker who had been involved in 2001 accepted the responsibility again, as the 2002 version of the assignment appeared to be more manageable than in 2001. Also, since it was the intention to compare the performance of students in 2002 with that of students in 2001 (see Chapter 6) it was important to keep as many variables as possible unchanged. Having one marker would ensure consistency of marking. It would have been possible to divide the marking of the two tasks between two different people, but at that stage no one else was available who had had experience in the assessment of portfolio-type mathematics projects.

Secondly, the simplified version of Task B enabled students to score well without actually putting in much effort. It only became clear in 2002, when all students were required to do both tasks, that it was possible for a student to tackle an ambitious example, without having the insight to relate the content to the required mathematical concepts. Such a task would thus not have satisfied the criterion of testing understanding, and the student would then have obtained a low score for the task. Also, there were many cases in which students scored high marks for trivial tasks, since the level of complexity of the task had not been specified in the stated criteria. Although in cases such as these the questions were coherent and tested understanding, the level of understanding demonstrated by trivial tasks was very superficial. A student could thus choose a trivial example in which clear solutions and correct mathematical terminology were almost self-evident, and score well.

Thirdly, since Tasks A and B each contributed 50% of the total, many students scored over 50%. High marks in the assignment may have had a positive effect on the final mark, but it was felt that under these circumstances high marks were not necessarily a true reflection of the standard of a student’s work. For this reason the assignment was again not used for the purpose of adjusting the final total.

Fourthly, it seemed that the task was not equally relevant for all students. One student commented (A202) that

> *Searching for relevant page numbers, when you already know what is wrong and how to answer correctly is a waste of valuable time. The important point is knowing how to answer questions, not to know where it is located in the textbooks.*

For the better students this may well have been the case. For the weaker students it would have been helpful if they had not only found, but also studied, the references; there was no indication that they had done so.

Finally, students still did not clearly understand the instructions. They were told that all the answers given by FS were either totally or partially wrong, yet again many students did not find all the mistakes.

Possible reasons for the problems experienced by the students

Many students could not understand the guidance given with respect to the selection of suitable material for Task B. Although an example had been given to show what was meant by 'testing content in a coherent way', several students simply copied that example (even copying the error that had been missed during proofreading). This could be a reflection of poor reading ability, since better readers may grasp more readily what is expected from them; it may also be that students simply tackled the assignment in a hurry, without really reading the instructions. In 2002 students were expected to submit both tasks, which may have been an unrealistic expectation, in terms of the time and effort required to attend to both tasks effectively.

Modifications made after the second action research cycle

Analysis of the results obtained during the second cycle had already led to the conclusion that the project might have been too idealistic for Mathematics Access Module students. In 2002 the marking of the project assignment was completed by the middle of August. UNISA scheduling procedures determined that the 2003 assignments needed to be set by the middle of June. At that stage the results of Assignment 3 of 2002 had not yet been received or analysed. If these results had been available, Task B would have been omitted in 2003. Since this was not possible it was decided that in 2003 Task B would in general not be marked in detail, for several reasons. For instance, student enrolment had increased again in 2003, and there was still mainly only one person marking this assignment[12], and it had become clear that students were unable to cope with Task B. Except in isolated cases Task B was

[12] This time she was assisted by the module leader, Carol Bohlmann.

thus superficially marked, i.e. some comments were made where applicable, so that students would not feel they had wasted their time. For Task A the mistakes, explanations and references were better aligned with one another, and there were 24 items in each category.

7.5.3 The 2003 results

The 2003 results are summarised in Table 7.7.

Table 7.7:

Overview of marks achieved in project assignment, 2003

Number of students	Mean mark (%)	Median mark (%)	Mode (%)	Minimum mark (%)	Maximum mark (%)
1 009	23,7	22	24	0	84

In a few cases students did not do Task A. Rather than penalise them, Task B was marked instead and the Task B mark was awarded for the assignment. Where it was evident that students who had done Task A had also taken of lot of trouble with Task B, it was also carefully marked. In such cases the Task B mark was usually higher than the Task A mark, and both marks were taken together and converted to the final percentage for the assignment.

In Task A student performance was of a similar standard to that in 2002. However, a very disillusioned student wrote the following comment (A300):

> *I don't understand Task A. More especially Interval Notation and Set Builder. I am struggle from distance Learning. Please try to help me where I'm went wrong. and Could you please Suggest me about the Examination Purpose. Because since I did Maths at Grade 9, the Unisa Career Adviser batrayed me to took MAT-011-k as the Major Module. It was better to stay at Home free And I did nothing. That to Hunt whath I Can't kill.*

(This student obtained 3/50 for Task A, and did not obtain examination admission.)

In Task B it seemed that more students ignored the issue of coherence, and simply selected very simple scenarios for each of the concepts on which they chose to set a question. There also seemed to be a greater incidence of meta-cognitive problems (see 7.6 below).

Correlations of the examination marks (P) against the Task A and B marks are shown in Table 7.8. Since only 571 students wrote the examination, only the assignment data relating to these students were taken into account. These correlations are comparable to the 2001 results.

Table7.8:

Pearson correlation coefficients r between M and P, and between T and P, 2003

	P score (%)	M score (%)	T score (%)
P score (%) (exam)	-	0,39570 < 0,0001*	0,39441 < 0,0001*
M score (%) (Mistakes noted)	0,39570 < 0,0001*	-	0,89211 < 0,0001*
T score (%) (Total for task)	0,39441 < 0,0001*	0,89211 < 0,0001*	-

*Correlations are highly significant.

7.5.4 Results in general

From Tables 7.2 and 7.5 it is clear that performance in Task A improved from 2001 to 2002. What is not clear is whether the improvement occurred in response to clearer instructions, or as a result of the inclusion of repeat students. If the performance of repeat students played a significant role, one would have expected a similar improvement between the 2002 and 2003 results, which was not the case, as can be seen from Table 7.7 From a mean of 16,3% in 2001 to 34,7% in 2002 the marks dropped again to give a mean of 23,7% in 2003. However, in 2002 and 2003 students were expected to do both tasks, and the gains from clearer instructions may have been negated by the time demands of two tasks.

It would have been possible to perform other statistical procedures, such as factor analyses and ANOVAs on the data available, but this was not done. Several other variables could also have played a role, such as the performance of repeat students, and the length of time students spent on the different tasks. No further statistical analysis was undertaken.

7.6 Additional findings

Although the main aim of the project was to investigate student performance on the stated criteria, a number of other aspects emerged as well. As these aspects emerged, assignments were flagged for further consideration. With the large number of assignments needing to be marked over a two-month period, by only one person, it was not possible to go through all assignments to try to discover all the problems. The marker flagged many assignments, and the module leader scanned these and many others when they were returned to the Mathematics Department, before being posted back to students. Selected sections of the assignments were photocopied, and the aspects that emerged were rather roughly distributed among various categories, created to 'fit' the aspect identified. No attempt was made to quantify the occurrences, but there were sufficient in each case to justify the creation of that category. The 2001 assignments were scrutinised in more detail than the assignments in 2002 and

2003. However, no claim can be made as to the comprehensiveness of the investigation into any of the aspects that emerged. In addition, in certain assignments some of the more obvious errors attracted attention and to some extent obscured other errors.

7.6.1 Reading/language problems

The photocopied comments reflect serious difficulty in comprehension and communication in English. Note the virtually unintelligible comment one student wrote in response to an incorrect answer (in 2003). The following question was asked:

> Working together, Tumelo and Jan can sand a floor in five-eighths of the time that it takes Tumelo to sand it by himself. Tumelo takes six hours to sand the floor alone. How long does it take Jan to sand the floor by himself?

FS's answer was logically incorrect and poorly presented. The student indicated that the answer was wrong, and made the following comment (A135):

> *It says of the time so buy know you know that you must divide because there is of no multiplying.*

The language and reading problems that were noted were broadly classified into several categories, outlined below. Some of these categorisations arose from an increased awareness of reading difficulties that had emerged from the three phases of the reading intervention, for example the use of prepositions, and anaphoric referencing.

Terminology: This was the largest category, where students used the incorrect word or phrase, for example *solving* instead of *simplifying*. They also used *cross multiply* for *cancel*, for example (A4):

> *We start with brackets first We find the LCM Change* -3 *to a fraction And cross multiply*.

Prepositions: There appeared to be considerable confusion with the meaning and purpose of words such as *to*, *by*, *with*. For example (B36):

> *Mr McCarthy want to send his car through the railway line. Assuming that the distance from Zimbabwe to South Africa where he will send the car is 2000 km. The train moves from Zimbabwe to SA with a speed of* $15{,}2 \times 10^7$ ms^{-1}. *How long will it take the train to reach SA.*

Quite apart from the fact that at this speed (which the student did not realise was impossible) the train would have reached Pretoria in approximately 0,0013 seconds, it is clear that '*through* the railway line' is inappropriate: how does such a student interpret an instruction such as 'Draw a line *through* the vertex'?

Reading: This category included various remarks which indicated that students have *heard* certain words, but do not know what they look like in written form, for example (A69):

You suppose to divide through by 6 *and do …*'.

Because *suppose* and *supposed* sound the same, students do not always distinguish between them. Examples in this category also showed that some students did not realise that reading implies the construction of meaning. A student (B48) wrote out an article with the heading 'Anglo and Impala Platinum results come under scrutiny'. The last two sentences in the article read: 'Supply concerns helped hoist Platinum to a fix of R5 834 an ounce this week. On Friday spot platinum was at 690 dollars.' In a question designed to address units of measure, the student asked:

Suppose R7 *buys one US dollar. How many US dollars, do the supply helped hoist platinum to a fix money in rand.*

It is difficult to know how much of the article the student understood.

Translation: This category incorporated examples where students showed that they did not know how to write what was expressed in words in symbolic or numerical form, for example (A42):

Jan's time = x

Then don't write x + 6 *because Jan's time is not* 6 *times more than Tumelo's time.*

As is often the case, the student was confusing 'six times more' with 'six more than'.

Anaphoric reference: Students were often confused regarding what words such as *it*, *this*, *these*, referred to, or how to use such words correctly in their own explanations. These words were often simply omitted, for example (A126):

x^2 *is incorrect because is not inside the bracket.*

On the other hand they were inappropriately used, for example (A107):

You need to get 0.625 *kiloampere to A, so that it is in scientific notation, by multiply it by* 10^3 *A. Then you must multiply it by* 10^{-3}, *you will get your answer.*

In this explanation it is not clear what the word *it* refers to, the second and third time it is used.

Causal relations: This category incorporates examples which illustrate problems students had with words such as *since* and *thus*, for example (A73):

Equal signes a not used in the correct manner. Thus k method is the easy way to solve this equation.

The second sentence is clearly not a consequence of the first. (Note also the student's use of 'a' for 'are'.)

Comparisons: In (A110), we read

Hence Sarah and Pete both performed better. The bothe got 9 wrong ….

It appeared that *both …better* was intended to mean *the same*.

The instructions regarding the completion of the tasks were (particularly in 2002 and 2003) clear and concise. However, the students' limited English language proficiency at the productive level may have been indicative of severe problems at the receptive level as well, so that the written instructions regarding the completion of the task may still have been above the comprehension level of many of the students. If this were the case, the study guides and assignments would equally have been beyond their comprehension. Conventional assignments contained more 'mathematics' and fewer 'words' and could, in some cases, be based on examples provided in the study guides. This fact may have obscured the severity of the reading comprehension problem in previous years. The prevalence of poorly developed language and reading skills suggest that students would also have been unlikely to interpret clearly or benefit from the comments made by markers on their assignments.

7.6.2 Number sense

Several answers illustrated poorly developed number sense. For example (A81):

> *Sarah and Pete got the same marks the difference is that Pete's assignment was out of* 45 *and Sarah was out of* 25, *do not confuse the 2 because they both obtained the same marks no one is higher than the other.*

7.6.3 Meta-cognitive problems

The comments made by the students in relation to FS's assignment also reflected a number of meta-cognitive aspects, which are not directly addressed in the Access Module study material. It is doubtful whether students who have not acquired a certain fundamental set of reasoning and academic skills *before* they begin to study at tertiary level will be successful.

The examples reflecting meta-cognitive problems have been broadly distributed among the a number of different categories, listed below.

Understanding of academic issues:

In one case (A142; in this example the mistake involved the incorrect manipulation of units and of exponents) the student wrote:

> *The full writing of kiloampere and milliampere is not good because it will cause confusion and wrong spelling. Use abbreviations, e.g. centimetre = cm.*

The question had nothing to do with length, and the centimetre example was quite irrelevant to the problem.

The following example illustrates a similar lack of understanding: In the assignment (2001) the question stated:

> Suppose Sipho earns 25% less than Susan does. How much does Susan earn if Sipho earns *r* rands?

The answer provided by FS, was the following:

> If Sipho earns 25% less than Susan does then Susan earns 25% more than Sipho earns. Hence Susan earns R(*r* + 25% *r*), i.e. R1,25.

The ‘marking’ carried out by the student showed that he did not notice the inaccurate mathematical reasoning; it also showed just how little he comprehended the nature of studying mathematics. He wrote

> *If you write your answer in mathematical symbol and forget about English phrases you will be able to get the answer*.

Sense making: Students demonstrated limited ability to reflect on the validity of answers: For example (B29):

> *He will be able to pick* 3062½ *nectarines in a working day*.

In the Spiderman example (B24), the student stated

> *Spiderman eats* 3/7 *bananas per day*.

In the example earlier featuring a train travelling from Zimbabwe to South Africa (B36), the student gave the time of the trip as 0,013 seconds, and seemed to have no sense that this is impossible.

Clarity of answers and explanations: In many cases students showed a lack of awareness that answers need to be intelligible. This category includes comments which were difficult to classify under any other heading, as they made no sense at all, for example (A76):

> 1 g = 10 kg *which is gonna* (10^{-3}) *if we multiply* (3 *expression*).

A more alarming example (B38: this student obtained 12% in the examination) reads as follows:

> *Suppose that the is a man in your area who have three wifes, and he has a tree of oranges, so he wants to give some to his wifes and he must give the same amount of oranges and must come home empty handed. When he crosses the first street to the first wife nothing happens, but when he crosses the second and third streets, all the oranges he is left with become multiplied by 2. This man needs your help. Estimate how many oranges must this man take from a tree, and how many must he give to each wife.*

7.6.4 General knowledge problems

Task B was designed to give the students an opportunity to relate the mathematics they were studying to real-life situations. It had not previously been considered that students’ general knowledge would in many cases be too limited for this to be possible. It now appears that limited general knowledge possibly also impedes students' ability to learn from examples that are used in the study material to illustrate mathematical concepts. Many of the problems in the general knowledge category also illustrate weak meta-cognitive skills, in that students seem to have limited ability to make sense of their answers. Examples illustrating general knowledge problems have been summarised under various headings.

Limited understanding of money matters, such as buying, selling, profit, for example (B8: student obtained 26% in the examination):

> *At the beginning of the Feb (end of January)*
> *Stock take was:* R 600 *At the end of Feb*
> *Stock take was:* R 400
> *Amount of stock sold:* R 200
> *Sales for Feb was:* R5000. *Therefore*
> *Profit* = R4800 *because*
> *Profit = Sales – Cost of sales*
> = 5000 – 200
> => 4800

The student seemed not to have considered whether such a profit was realistic, in relation to the initial stock value.

In another example (B37; the student did not write the examination[13]) we read:

> *Suppose that South Africa and Botswana had entered into the financial market stating that to go to Botswana is* R5 000.00 *from South Africa. Every time each person travel from South Africa to Botswana gets something. Using financial matters as an indication of that ratio, what would that ratio be?*

The answer suggested that the student was trying to calculate the exchange rate between pula (Botswana currency) and rands (South African currency) without appreciation of the principles involved.

A sense of order of magnitude: In the game farm example noted previously (B4: student did not write the examination), in the question dealing with conversion of units of measure the student worked out the capacity of four dams, as 1 500 litres, 250 litres, 2 000 litres, and 500 litres, respectively, and did not realise that in real life the capacity of even a small dam would be considerably greater.

[13] In the case where no examination mark was available it was not possible, at the time of writing in 2004, to go back to the previous three years' records to find out whether the student had obtained examination admission or not, whether the student had dropped out after submitting Assignment 3, or whether the student had obtained

Problems with distance, speed and time (some of which could also be placed under the previous heading). The concepts of distance, time and speed, which are fundamental to many illustrations of mathematical concepts, are problematic for many students. Many examples featuring distance, speed and time involved unrealistically fast or slow speeds, impossible distances and superhuman times. For example (B31: student obtained 20%) the student wrote:

> *Suppose nomsa travel at a speed of* 8×10^5 ms^{-1} *in* 15 *s to the shop to buy food. How far is the shop from her home.*

She then proceeded to calculate as follows:

$$d = s.t$$
$$= 8 \times 10^5\ ms^{-1} \times 15\ s$$
$$= 1{,}2 \times 10^7\ m$$

and left the answer like this. She did not understand what these numbers imply, namely that

- it is unlikely that it would take 15 seconds to travel from home to a shop
- no one can travel at a speed of 8×10^5 ms^{-1} (i.e. 2 880 000 km/h)
- no one would travel a distance of $1{,}2 \times 10^7$ m (i.e. 12 000 km) to shop for food.

A similar problem, where the speed is also impossibly fast, appears in B39 (student did not write the examination):

> *If an aeroplane travels at* 12×10^8 ms^{-1}, *how long did it take for the equipments of the mobile services to reach Johannesburg from Europe.*

The student did not realise that the aeroplane's speed was thus 4 320 000 000 km/h, clearly impossible; the student's answer, with no conception that this was also impossible, was t = 0,0075 seconds.

Unrealistically slow speeds appeared as well: a student wrote (B34: student obtained 11%):

> *Sipho travelled* 2 *hours to go and take the money and the plane was moving with* 30 *m per minute.*

The student presumably did not grasp the fact that even a slow walker would travel faster than that, or that no aeroplane could fly so slowly.

Apart from problems involving order of magnitude, discussed above, there were many unrealistic or incorrect examples, such as the case of someone going on holiday to the USA (B9: student obtained 33% in the year-end examination, and did not write the supplementary examination). In one of the questions the student tells of the person being invited to go hunting, where the group would be '*hunting for* 2 *hours at* 16 *miles per hour*', a completely unrealistic situation.

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examination admission and had decided not to write the examination.

There were several examples in this category that were quite meaningless, for example (B42: student obtained 31% in the end-of-year examination and did not write the supplementary examination):

> *If Implats is in cape Town and Goods are supposed to be transported to Durban by ship. How far is Durban from cape Town? If the ship is travelling at 18 m.s*$^{-1}$ *and the voyage took about 60 seconds*.

After carrying out some calculations the student wrote

> *It took 1 080 m to deliver goods*.

Understanding of units: A student gave the following example (B32: the student obtained 42% in the year-end examination, wrote the supplementary examination, and obtained 25%):

> *Topsie is sick in hospital, his body temperature is too high, about* 50^{0C}*. A doctor in another Country wants to know what the temperature is, the problem is that he does not use* 0^{C} *but kelvins (k). What is the temperature of Topsie in kelvins*?

The answer is given as 50 + 273k. The student had apparently never learnt about normal body temperature, or the way it is usually measured, and also had problems with the notation used for units of temperature.

In an example based on Eskom[14] price amendments (B23), the student asked the following question:

> *Calculate how many volts the crane needs in order to use equal volts as the train does.*

It is difficult to imagine a real-life situation in which such a calculation would be necessary, especially since Eskom charges for the amount of energy used, and not the voltage. In spite of this problem, the student passed: he obtained 41% in the year-end examination, wrote the supplementary examination and passed with 53%. However, it should be noted that this student's assignment was mentioned above as an example of a good task B; also, he obtained 82% for Task A.

The meaning and purpose of estimation, calculation, and approximation: In the tuck shop example (B8: student obtained 26%), the student stated that R400 was spent on petrol, and that there would be an increase of 10% in the petrol price. She asked what the *estimated* increase in petrol expenditure would be. In a case like this, the numbers are so simple that no estimation was needed. The student had no real understanding of the difference between estimation and calculation.

Understanding of geographical concepts: In one example (B33: student did not write the examination) a student wrote out a newspaper article, and proceeded to ask

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[14] South African supplier of electricity

Suppose you need to travel by car from JHB[15] *to Australia at a constant speed of* 200 *km/h, and the distance is* 2000 *km. Calculate the time it would take you to reach Australia.*

Such limitations of geography and motoring potential are severe.

Another student (B35: student obtained 24%) discussed the spending of a government grant. In one of the questions the student asked following:

Suppose the union building is 10 *km from eastern cape*[16] *then people send complains about this grant by internet travelling by 3.4 seconds then how long will it take the letter to reach union building.*

In another example a student wrote (B40: no examination mark)

Assume that USA lies 10 km from Cape Town …

and in a similar vein (B41: no examination mark)

Assume that Harare is 10 000 *km from J.H.B …*[17].

7.7 Discussion of the results

One of the reasons for attempting this intervention was to determine the potential for an assignment of this nature to contribute more to the formative assessment process. In the light of poor performance, and without individual student follow up and in-depth investigation, it is difficult to know to what extent the marks reflect student competence levels, and to what extent students benefited from the project. The marker provided written comments on individual assignments, and printed solutions were sent to all students. Apart from the individual feedback and the printed solutions, in 2002 students also received an additional tutorial letter containing general feedback on the assignment. The additional information was provided to help students determine whether and why they had made mistakes. However, from discussions with students it is clear that they generally just put the assignment away once they know what mark they obtained. This is not unusual student behaviour (see for example Mason, 2002). The belief that the mark is what counts is also very deeply ingrained after twelve years of (often ineffective) schooling. It is thus difficult to know whether students used the assignment as an opportunity for learning.

An alternative approach to assessment was implemented over a three-year period primarily as a way of facilitating more effective learning, in the sense that ‘effective learning’ would translate into greater success (in terms of examination performance). The (implicit) assumption was made that practice in engaging more deeply with the study material (the intended focus of Task A) and closer alignment of

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[15] An abbreviation sometimes used for Johannesburg.
[16] This distance is well over 1 000 km.
[17] This distance is approximately 1 000 km.

mathematical concepts with every day activities (the intention of Task B) would enable students to understand mathematical concepts better, and thus perform better in other types of assessment tasks, such as the end of year examinations. This did not take place, possibly because the assumption is too idealistic, and learning benefits are not transferable under these circumstances.

Apart from using the project as a learning opportunity, it was also the intention to use the marks as a component of the students' final marks (see Chapter 8, Section 8.2.3). Poor performance in the assignment meant that students earned very few credits towards examination entry, or towards potentially increasing their final marks. The results in 2001, 2002 and 2003 suggest that the project did not have a significant impact on students' success. Furthermore, with high enrolment figures and budget constraints (limiting marking capacity, among other things) the project seemed to be impractical.

The project described in this chapter was intended to provide an opportunity for creative, meaningful and realistic applications of mathematics, but it is not clear whether these goals were realised. Without personal contact with students, the only conclusion that can be made is that the assignment did not appear to yield much learning benefit, or boost the marks sufficiently to have had any positive effect on the examination results. It may also have had a negative impact in that poor results could have discouraged students.

Low marks in the project may also relate to students' priorities. The examinations did not contain any questions similar to Task A or Task B. Students generally receive the assignment questions for each year towards the beginning of the year. One of the assignments has been the previous year's examination paper. Students thus knew in advance that project-type work would not be examined, and possibly chose to put less time and effort into what they may have considered a less important assignment.

It is of course true that different assessment tasks appeal differently to different students, which is one of the main reasons that good assessment practice involves a variety of assessment methods. In the analysis of the results in 2002 there was a weak correlation between Task A and Task B, possibly suggesting that students who were interested in engaging with real-life issues which interested them were not interested in considering a hypothetical student's problems. In 2002 Task B in general pushed up the total project mark, but in that year the correlation between the assignment mark and the final examination mark was the lowest. In 2001 and 2003 the examination mark correlated more strongly with the assignment mark, which reflected performance in Task A. From the weak correlation between the Task B mark and the examination mark in 2002 it may be possible to infer that students who were willing to spend time and effort on real-life activities, and who demonstrated insight and understanding of the concepts involved, were not necessarily able to perform equally well under the time pressure of examination conditions. Students who score well in one type of assessment, may not score well under different circumstances (see for example Dunbar & Witt, 1993). It would then seem to be even more important to include a significant component of investigative work in the students' overall assessment.

The CRESST study (MSEB, 1993) points out that better readers may grasp more easily what assessment tasks require (see 7.3). The additional findings described in 7.6 show that many students experienced reading and/or language related problems. It was evident from the students' written work that they had limited ability in expressing themselves in English: could the underlying problem be that they could not read well enough to make sense of what they were reading? It is important to address this question before problems undermine academic performance.

7.8 Summary

In this chapter we have considered the use of a project, involving two tasks, over a period of three years. We considered the tasks in the context of UNISA assessment policy and guidelines. The rationale for using a project was discussed. The two tasks and the marking criteria are described. The aspects of student performance that were investigated are discussed, and the results for each of the three years are given. The analysis of the results each year led to some modifications in the way the project was implemented in the following year, resulting in three separate action research cycles.

The additional findings that emerged from the three action research cycles described in this chapter reflected a number of reading or language problems that were a barrier to mathematical conceptual growth for Mathematics Access Module students. Students also experienced many problems as a result of weak meta-cognitive abilities and limited general knowledge. There are thus many aspects that, taken together, may determine a threshold for learning mathematics effectively.

The results obtained from all the action research cycles described thus far led to the investigation of a further intervention, and the final action research cycle described in this thesis (an investigation into diagnostic assessment, discussed in Chapter 9).

In the following chapter we first review student performance over the years in which the interventions described in Chapters 5, 6 and 7 were implemented.