CHAPTER 10

FROM ACCESS TO SUCCESS?

10.1 The end of the research cycle

This chapter reviews the previous nine chapters, and reflects on a number of aspects that have emerged from the research that was undertaken. It includes some general reflections on the results that were obtained, notes the limitations of the research and makes some suggestions for future research, in the hope that some of the lessons learnt might result in improvements for future students, at UNISA in particular and possibly elsewhere.

10.1.1 Content and context

In studying mathematics students should ideally be exposed to 'real' mathematics, and have a sense of its epistemological nature. The Education Committee of the American Mathematical Society sponsored a meeting in January 2004, at which Lynn Steen emphasised that mathematics is by its *essential* nature 'interconnected and multidimensional, where distant parts link through logic and common structure' (Steen, 2004). Linking different strands of mathematical knowledge is only possible when students have access to resources, access to the study material through access to appropriate media and the skills to utilise them, and access to support where necessary. Only then can they develop an overview of the concepts they are learning, and the relationship of the concepts with one another and the world about them. In other words, providing access implies not only the provision of content but also context: creating appropriate conditions for learning is as important as selecting relevant mathematical topics.

In spite of all the attempts to make improvements and implement different interventions in order to achieve greater student success, the low pass rates and high attrition rates suggest that the goal was not achieved: does this translate to failure? Although the Mathematics Access Module has made it possible for some students each year to have access to further study of mathematics at UNISA, the numbers have been too small to claim that the Mathematics Access Module successfully provided access to tertiary mathematics. In the process of investigating aspects of the module and students' needs, a number of issues emerged, each requiring some form of intervention. Each intervention opened up other areas for investigation and intervention that had not previously been as clearly perceived, and led to new insights. If failure to achieve the set goals led to other results, then 'failure' possibly has too negative a connotation. However, the research results have highlighted significant challenges for the teaching of the Mathematics Access Module, and for future mathematics modules students may take. In Chapter 1, Price (1997) makes it clear that students for whom previous access to mathematics has been limited will find it difficult to succeed in *mainstream* mathematics courses in South Africa. From the previous chapters it would appear that large numbers of disadvantaged students have many problems coping with mathematics at an even lower level.

10.1.2 Overview

Chapters 1 and 2 provide the context and theoretical background of the research described in this thesis. Chapter 3 describes the research method used. Chapter 4 describes the steps that were involved in providing both content and context for learning, during the period from 1997 to 1999. In 1997 and 1998 there was only a Mathematics Access examination; poor results led to the creation of study material and some teaching support. Over time the *content* of the Mathematics Access Module appeared to be relevant and acceptable, but it became clear that the learning *context* required attention.

Interaction with students led to an understanding of some of the problems they were experiencing, and created an awareness of the need to do more to assist them to reach the required threshold for learning mathematics. This ‘need to do more’ resulted in ongoing attempts to provide additional support for students, and two parallel sets of interventions. There were thus two corresponding parallel sets of action research cycles in which the interventions were studied. Chapters 5 and 6 deal with one set of interventions and the associated action research cycles; Chapter 7 deals with a different intervention and the related action research cycles. Each cycle led to a deeper understanding of the issues involved, and hence to a modified form of that intervention, or to a new intervention. The parallel sets of action research cycles led to the final intervention described in Chapter 9. We now review the different chapters in more detail.

10.2 Review of Chapters 1 to 9

10.2.1 Chapter 1: Background and context

Chapter 1 reflects on the importance of mathematics and the national and international concern regarding access to tertiary mathematics. The problem arises from two main factors: discontinuity between secondary and tertiary education, and social inequities resulting in uneven participation and performance among certain groups. Some of the problems that are of particular concern in the South African situation were highlighted, such as the socio-economic challenges of the home environment, poorly qualified and poorly trained teachers, ineffective teaching and learning styles, overcrowded classrooms and weak school management.

The performance of the South African Grade 8 learners in the Repeat of the Third International Mathematics and Science Study (TIMSS-R) in 1999 was poor (Howie, 2001). Apart from the actual results, the further deterioration in results, in comparison to the 1996 results (reported in Howie, 1997), was cause for concern. The 1999 Grade 8 learners would theoretically have matriculated in 2003, with many of them possibly planning to enter tertiary education. It is unlikely that the poor levels of attainment have been remedied (the 2003 matriculation results reflect that the percentage of HG passes in mathematics, for all students who wrote, was approximately 7,9% (Department of Education, 2004)). Study opportunities in the sciences at tertiary level are closed to mathematically unprepared students, and it thus seems that the need to provide access to mathematics at tertiary level is likely to continue.

The role of distance education as a potential provider of access to mathematics is also considered, although it is clear that disadvantaged students may not necessarily possess all the skills required for independent study. The constraints of distance teaching in South Africa are significant, such as limited interaction, the focus on print as the medium of delivery, and poorly developed academic skills of students entering tertiary education.

The responses of several tertiary institutions to providing are considered. The unique role of UNISA as the only institution capable of addressing the problem on a large scale is also emphasised. UNISA began by creating a Mathematics Bridging Module in 1993, but it soon became clear that large numbers of potential students were still excluded. In 1997 UNISA for the first time accepted students without matriculation exemption into the Bridging Module, provided they had passed a Mathematics Access examination. This examination was the first step leading to the development of the Mathematics Access Module. A diagram (Figure 1.1) explains the various entry routes into first-level mathematics modules.

10.2.2 Chapter 2: Literature review

Chapter 2 gives the theoretical context for this research. Some of the issues relevant to learning mathematics are considered, such as a variety of cognitive factors, the mix of teaching approach and learning styles of students, the impact of background and linguistic competence, students' meta-cognitive ability, and a number of affective factors. The mismatch between the conditions under which mathematics learning flourishes, and the conditions under which learning takes place for many South African students, is evident. The particular problems experienced by disadvantaged students attempting to study mathematics at a distance are also noted.

10.2.3 Chapter 3: Research design

In this study there was first a pre-research phase, during which a Mathematics Access examination was provided; after two years study material was then written. Poor results led to two different but parallel sets of interventions. Circumstances dictated that ongoing improvements in teaching and support, as well as the two parallel sets of interventions and associated action research cycles, took place simultaneously, so that it was never possible to investigate the impact of any one aspect in isolation. Attempts to compare examination results with the results of a specific intervention are possibly suspect, but were nevertheless undertaken.

The analysis of the results after each intervention phase, and the resultant modifications which were made for the next intervention phase conformed to an action research model, involving the characteristic stages of planning, acting and observing, reviewing and modifying, in consecutive cycles. The one set of interventions, into the relationship between reading skill and mathematical performance, took place over a four-year period, from 2000 to 2003. It consisted of four different phases, and resulted in four separate action research cycles. A second intervention, into alternative assessment, took place over a three-year period, from 2001 to 2003. Three action research cycles were associated with this intervention, one in each year. There were some modifications from year to year. Results obtained from the four research cycles of the reading intervention and from the three cycles of the assessment intervention together led to the final intervention, namely a preliminary investigation into a diagnostic assessment process, and an associated action research cycle.

Chapter 3 also notes several factors that played a role in the conceptualisation and implementation of several interventions, and outlines the context in which this study was undertaken. It was necessary to work within a given situation in which English was the language of instruction. It was also necessary to define ‘success’; in this case success was defined as passing the Mathematics Access Module examination. Furthermore, in the given context, selection and placement were not options at the beginning of the period described by this thesis, but diagnostic assessment, with a view to assisting students in making their own ‘placement decisions', became an option at the end. The study was also affected by the limited availability of data, and a number of institutional factors.

10.2.4 Chapter 4: Creation of study material and initial support options

The main reason for introducing the Mathematics Access Module was to improve access to mathematics. This was defined in terms of creating opportunities for students who could not yet enter mainstream mathematics to engage with and understand the mathematics required for further study at tertiary level. To this end an examination-only option was first introduced; limited success led to the provision of study material, assignments, and some support in terms of tutorial classes, discussion classes and face-to-face support; however, the support only reached students in certain geographical areas.

In Chapter 4 there is a switch from a broad focus on access in general to a focus on a specific UNISA module, the Mathematics Access Module. The purpose of the module is explained, and the chronological development of all the activities associated with the module is given: the introduction of only a Mathematics Access examination in 1997, leading to a taught module supported by study guides, which were produced in 1999.

The study material was developed within a particular philosophical and pedagogical perspective. Outcomes-based education and SAQA requirements were external factors needing to be accommodated. A sense of the kinds of students for whom the module was to be designed, and an awareness of the knowledge and skills they would need to have acquired by the end of their studies, led to the decision to emphasise, as far as possible, understanding within an interactive context in which students would be able, within limits, to construct their own understanding of concepts, related to relevant aspects of everyday life. The term 'understanding' was expanded to mean 'relational understanding', i.e. knowing what to do and why, although it was pointed out that in some cases automatisation of algorithmic skills is also important. To achieve understanding, deep learning was encouraged above surface approaches to the content, and scaffolding was built in to facilitate conceptual development. Students were encouraged to build up their understanding by making use of various activities in the study guides (such as examples with worked-out solutions, activities for which detailed solutions were given, and exercises with answers or, in some cases, more detailed solutions) and by doing and submitting assignments.

The study material incorporated a number of instructional design principles, intended to facilitate learning, such as the use of Checklists, Topic Summaries, user-friendly language, and language support (in the ‘Ways with Words’ items). Cognitive load imposed by the text itself was reduced as far as possible, for example through consideration of font size and layout, referencing, and the use of margin notes.

Content was selected according to internationally accepted norms, to equip students to cope with the mathematics they would need in everyday life, and the mathematics required by modules they would be likely to progress to. Culture, race and gender inclusivity were taken into account in the types of examples and activities used to illustrate concepts.

The philosophical and pedagogical approach, as well as a number of practical factors, affected the nature of the formative assessment tasks. The study guides provided opportunities for self-assessment. From 1999 assignments could be set, based on the written study material. Initially there was limited academic contact: tutorial classes involving tutors, discussion classes involving lecturers, and some face-to-face sessions. Computer-marked assignments containing multiple-choice questions were also introduced. At the end of the year students wrote an examination, consisting of computer-marked multiple-choice questions. Table 4.2 shows that success was limited.

10.2.5 Chapter 5: Reading skill and learning mathematics

Students’ difficulties in engaging with the study material also appeared to be related to the extent to which they could read the material in a meaningful way. This led to an investigation into reading skills and to two attempts to address the reading problem, as discussed in Chapter 5 and Chapter 6.

Chapter 5 documents the first two phases of a reading intervention project. Phase I, in 2000, involved an investigation of a possible link between reading skill and learning mathematics. A set of reading tests was developed, using mathematical texts from the study guides that students would have been using, and other texts as well. It was piloted on a group of volunteer students studying the Mathematics Access Module. The results of these tests were analysed, refined and finally (towards the end of 2000) administered to all registered Mathematics Access Module students. The main finding was that, while good reading skills cannot guarantee good performance in mathematics, weak reading skills appear to be a barrier to success. It appeared that students with a reading score (based on a number of component skills) of below 60% were also those who were failing their mathematics.

Phase II of the project involved a reading intervention programme for a small group of volunteer Mathematics Access Module students. These students participated in weekly face-to-face sessions over a twenty-two week period. During these sessions they were taught relevant reading skills that had been identified in Phase I, such as the importance of academic vocabulary, aspects of mathematics discourse, anaphoric referencing, logical relations, and the reading of tables and graphs.

Through quantitative and qualitative research a picture emerged which supported the findings of Phase I: the students' reading skills were extremely weak to begin with (in this intervention programme reading speed and comprehension were also taken into account) and although there was a considerable improvement in reading ability, in many cases students had not yet reached the 60% threshold by the end of the intervention. Not surprisingly, these students also failed the Mathematics Access Module examination. By the end of the intervention students were beginning to grasp the importance of reading as part of their overall academic development, and their need to continue with activities that would improve their reading skills. This was an important contrast to an attitude prevalent among students who did not persevere with the reading programme: they felt that their reading skills were adequate, and thought that focusing on reading was irrelevant in a mathematics module.

In the analysis of Phase II results a number of verbal (such as matriculation language marks, reading pre-and posttest scores) and non-verbal variables (assignment mean and examination performance) were compared. The strongest correlation, which was highly significant, was between the reading pretest and the Access Module examination results. It was not clear why the correlation between the examination results and the posttest reading result was weaker.

10.2.6 Chapter 6: A large-scale reading intervention programme

In Phase III of the intervention two specific issues emerged. The first was the need to determine whether, and how, the findings of Phase II could be meaningfully extended to a large group of dispersed students. The second issue was the need to find a meaningful way of measuring the reading abilities of the majority of the students, given that the types of pretest activities implemented in Phase II could not be implemented in the same way, if at all, under circumstances where no control was possible.

To achieve the goal of reaching large numbers of students the video entitled ‘Read to Learn Maths’ was developed, together with a supplementary Video Workbook for students for whom video access might have been problematic. In order to find out whether this intervention was meaningful, some way had to be found to compare the students’ performance over a two-year period (one year with no video, and the second year with exposure to the video). A measure was needed to assess comparability of the two groups. In the absence of other information, only performance in the first assignment in each of the two years was considered, before students received the video. It was found that the marks of the 2002 students were slightly better than those of the 2001 students, but similar enough for the two groups to be considered comparable. However, in spite of the reading intervention, the examination results deteriorated from 2001 to 2002. The students did not appear to have benefited from Video 1 and the associated reading activities. The increase in pass rate in 2003 was encouraging, however, there is no conclusive evidence that the video (Video 2) brought about this change. It may have had some an impact, as the students would have had early feedback on their reading abilities through a ‘diagnostic reading test’ incorporated into the first assignment. This purpose of this test was to diagnose and quantify reading problems, in order to raise student awareness of the kinds of reading problems which could get in the way of effective study. The diagnostic test feedback encouraged students to use the video where necessary.

Apart from some form of diagnostic pretest, several reading activities were included (in three of the assignments in 2002, and in one assignment in 2003). These activities were also provided to motivate students to use the video material, rather than simply ignore it (because they assumed it did not deal with ‘real mathematics’). Analysis of these reading activities corroborated previous findings: students were reading slowly, with limited comprehension, and they demonstrated low overall reading ability.

The reading results obtained in Phase III also showed to a greater extent than before the problems students were having with the symbolic nature of mathematics discourse. ‘Reading’ mathematics requires the integration of language and mathematical (symbolic) decoding and comprehension skills, as well as visual literacy. Students seemed to lack the skills required to make sense of passages of text containing numbers, words, graphic devices and symbols. Many students also demonstrated limited meta-cognitive awareness with respect to checking whether what they had written (combinations of numbers, words and symbols) made sense when it was ‘translated’ into normal discourse.

The initial assumption that comparability could be established on the basis of the first assignment may have been invalid, and the two groups of students may simply have been very different in terms of ability. However, if they were in any way comparable, it would appear that the video intervention did not have the desired effect, and may even have had the opposite effect, in that the time required to do reading activities and to answer the reading skill sections of the assignments left insufficient time for students to get to grips with the mathematical content.

10.2.7 Chapter 7: An alternative approach to assessment

The pass rate in 1999 was low, in spite of the introduction of study material and assignments. Furthermore, in discussions with students it was clear that many of them were finding it very difficult to engage with their study material and relate it to everyday situations. These factors gave rise to a renewed focus on formative assessment. Chapter 7 focuses on the design of a project, consisting of two tasks which attempted to engage students in their studies in a different way. The project was set as one of the assignments each year, over a three year period. One of the tasks gave students the chance of ‘playing teacher’; the other gave them an opportunity to engage with the mathematics of everyday life. The results did not suggest that the project helped students perform better in the examination.

10.2.8 Chapter 8: Assessment and support

This chapter discusses the approach to assessment, the need to qualify for examination admission, and the introduction of additional measures of support, from 2000 onwards. The need to balance formative and summative assessment is important, particularly the need to help students view assessment as an opportunity for learning.

Table 8.1 gives an overview of the assessment practices for the Mathematics Access Module. Many of the assessment tools were chosen for logistical reasons, such as the use of computer-marked questions in assignments and examinations. With time, assessment practices changed.

The first change, in both formative and summative assessment, was the move away from computer-marked multiple-choice questions (CM-MCQs) to lecturer-marked questions (LMQs).

This change was linked to a number of other events, such as the increased availability of lecturers to see students, and tutorial classes held in additional centres around the country. It is thus impossible to consider the impact of the change in the format of assessment activities in isolation. However, the pass rate in the 2001 - 2002 examination period (when only LMQs were used) was lower than in the 2000 - 2001 examination period (when only CM-MCQs were used). The LMQ format possibly allowed for greater testing of understanding and application than the MCQ format had done; students favouring a surface approach to their studies were not necessarily able to achieve the deeper level of understanding that could then be assessed. In MCQs students can guess correct answers; in LMQs if answers demonstrate incorrect reasoning students do not obtain full marks just because the answer is correct.

The next change was an attempt to encourage students to put more effort into their assignments by allowing 10% of the marks obtained in one of the assignments to contribute towards the final mark, but this did not appear to have much effect. It is difficult to know whether the *policy* as such had little impact, or whether the problem lay with the particular assignments selected for inclusion or the sequence of those assignments. If the project assignment (Assignment 3) was too difficult for students to perform well in, as appears to have been the case, then it would not have had the desired impact. If the project assignment took up too much time, and left too little time for preparation for the next assignment (Assignment 4) then inclusion of Assignment 4’s marks may also not have served much purpose.

Another change involved the practice of allowing students with between 30% and 44% in the year-end examination to write the supplementary examination. This practice contributed significantly to the pass rate, as can be seen from the increase in pass rate each year after the supplementary examination results are taken into account (see Table 8.10). In 2002, for example, more than one third of the students who passed were able to do so as a result of this change.

In spite of different approaches to assessment, the pass rate remained low. Table 8.9 reflects precisely the opposite of Volmink’s ideal, namely that assessment should ‘reveal value rather than merely identify deficiency’ (1994, p. 63). Furthermore, the attrition rate continued to increase. Ongoing poor performance in spite of all efforts to improve the situation led to the final intervention.

10.2.9 Chapter 9: Establishing a process of diagnostic assessment

Each year, for increasing numbers of Mathematics Access Module students, success (in terms of passing the module) has been elusive. Experience of failure has probably eroded student self-image; attrition and failure have resulted in wastage of financial resources, both student and institutional. Factors such as these, supported by the research results obtained in the two sets of action research cycles, led to the final intervention described in this thesis, and the action research cycle associated with this intervention.

From Chapters 4 and 8 it can be seen that over the years there was a shift from the Mathematics Access examination, to which anyone who paid the examination fee was admitted (at that stage only an examination fee was charged), to a situation where examination admission depended on acquiring a fixed number of credits through assignment submission. Each year a higher percentage of registered students failed to obtain examination admission.

The findings of Chapters 5, 6 and 7 suggested that students without a certain set of fundamental academic and quantitative skills, including general knowledge and an acceptable level of English language and English reading proficiency, were unlikely to be successful in their studies. There was clearly a need to identify potentially at-risk students, and suggest appropriate support options or alternative directions of study. It was necessary to find some way of diagnosing risk before students committed time, money and energy to something in which they were unlikely to succeed. This led to the consideration of diagnostic assessment as a means of determining low-, medium- and high-risk categories of students (risk in relation to successfully studying the Mathematics Access Module). In particular, the diagnostic assessment was seen as a means by which current competence could be assessed early enough for remedial action to be taken, if necessary.

Placement testing and diagnostic testing had been seen to play a positive role internationally and at other South African universities. However, there were practical and administrative implications associated with the introduction of such testing in a so-called ‘open’ and distance-learning university like UNISA. In June 2003 the UNISA Senate accepted the proposal to introduce compulsory diagnostic assessment (the MDA) for all potential Mathematics Access Module students. There was recognition of the potential of such assessment to help students to identify their strengths and weaknesses (in terms of quantitative reasoning and reading) and to provide better guidance regarding appropriate directions of study, or to suggest appropriate support options. Identifying weakness without suggesting possible alternative directions of study or support options is unacceptable, and it was envisaged that various forms of advice and support could be provided by other departments within the university. It was agreed that the MDA and related support would be offered at no additional cost to the students.

In spite of time constraints, diagnostic assessment for mathematics commenced in 2004, with the further aim of obtaining information on procedures, processes and structures that are practical within the UNISA context. It was agreed that assessment should be based on internationally accepted standards, adapted if necessary to suit specific UNISA requirements. Issues of reliability and validity were to be considered in the selection of assessment tools, as well as the need for practical and cost-effective measures.

The MDA was not approved as a *prerequisite* to study, but as a 'compulsory'[1] co-registration requirement. It was thus only possible to offer advice to students, rather than apply the results rigorously in terms of who would or would not be accepted into the Access Module.

The main objective of the MDA was to identify risk groups. Three risk categories were identified, namely high-risk students, medium-risk students and low-risk students. The low-risk students were those who would have a reasonably good chance of passing the Mathematics Access Module by making full use of the study material and existing academic support. The medium-risk students would need considerably more support in terms of improving levels of quantitative and academic literacy, and would possibly benefit by reconsidering their subject choice under the guidance of experienced counsellors. The high-risk students were those who were considered to be unlikely to be successful without greater levels of support than the university could offer.

A number of assessment instruments were considered. The written version of the ACCUPLACER Reading Comprehension (ARC), developed and used for many years in the USA and already extensively researched in South Africa at the University of Port Elizabeth, was used to assess reading skill. Tests of mathematical ability (whether numerical or algebraic) that were available elsewhere included components that were pitched at too high a level for potential Mathematics Access Module students, and a UNISA-specific test for quantitative reasoning, called the Basic Arithmetic Test (BAT), was designed, even though reliability and validity could not be guaranteed in the short term. The findings of the reading intervention and ACCUPLACER guidelines were taken into account in the boundaries chosen for the risk categories.

[1] It was in fact not compulsory, since no action could be taken against students who elected not to write the assessment.

The action research cycle associated with the introduction of diagnostic assessment focused on the results obtained from an initial analysis of the data obtained from the January cohort, as well as data obtained from the June cohort. Initial analysis showed that the majority of the students who registered for the Mathematics Access Module were in the high-risk category. Preliminary investigations revealed that support activities did not necessarily take place as planned.

It was the intention that the MDA would be conducted over several years, in order to improve and refine the process. It seemed advisable that once the process had been introduced, the procedures could be reviewed, and further research could be undertaken, both quantitative (test refinement, comparison of student performance with respect to assignments and examinations) and qualitative (students' perceptions of the assessment process). Further research that could establish positive aspects of the MDA, such as predictive validity of the tests and improved retention of registered students, might lead to greater institutional and student support for the MDA. Diagnostic assessment would also be more effective if it could ultimately operate as a pre-registration placement assessment (rather than a co-registration requirement).

In the interests of true access it is important to improve the procedures and processes that were implemented during the first phase of the diagnostic assessment. Several directions for further research have been suggested, and the research results could lead to such improvements. The end of this action research cycle thus creates a platform from which a number of further cycles could be considered.

10.3 Some reflections

The picture that has emerged shows that providing access to mathematics is a complex matter, and that provision of study opportunities does not constitute access unless research, planning and mechanisms for minimising failure are built into this provision. The following section contains some personal reflections on a number of aspects relating to the Mathematics Access Module, the interventions and the action research cycles.

10.3.1 The design and evolution of the Mathematics Access Module

In the selection of content, philosophical perspective, and pedagogical approach, trade-offs were inevitable. It is unlikely that any educational context would facilitate the development and delivery of 'the perfect' course. At the time it was developed the Mathematics Access Module was the best that could be done, under the circumstances. Although the way in which the study material and assessment activities were designed emphasised understanding, it is important to recognise that understanding is not a skill, in that one cannot teach someone to understand. Rather, as Wood (1994) suggested, the goal of instruction should be to bring into being the kinds of cognitive structures that will *facilitate* understanding. Students need appropriate cognitive skills *already in place* if they are to be able to interpret and communicate within a specific mathematical context. In other words, for teaching to be effective there is a 'threshold' or minimum level of competence learners need at the commencement of the process. As Wood (1994) has said, 'As a matter of policy … academic development should concern itself with how to bring about a certain minimum of general and conceptual knowledge necessary for understanding academic discourse' (p. 169).

For many students from disadvantaged backgrounds, particularly those studying in a language other than the mother tongue after having been taught in yet another language (or combination of languages) at school, mathematical success at tertiary level is unlikely. It has been pointed out that many indigenous languages do not have sufficient vocabulary for mathematical and other scientific discourse. At UNISA the use of English as the medium of instruction, although inevitable, has certainly limited rather than extended access for students for whom reading academic texts in English was problematic. The reliance on an oral rather than a written discourse, and other environmental factors affecting reading attitudes and practices, have led to situations in which the ability to construct meaning from mathematical text written in English is particularly problematic.

The pass rate and attrition rate attest to the fact that the module has not lived up to its promise of creating access to mathematics. Tables 8.4 and 8.9 reflect the increasingly low pass rate (although this trend changed in 2003) and increasingly high attrition rate.

The whole process of designing material, introducing support and implementing different interventions was a dynamic one, as each set of changes led to a deeper understanding of existing problems, or to the recognition of problems not previously identified. In the process some useful insights were gained. However, although each 'improvement' was introduced in response to the difficulties students were experiencing, it may yet have led to further problems. The problems and issues that need to be addressed include the following.

Did the introduction of study material necessarily imply that students could engage with their study guides?

All the instructional design features used in the writing of the study guides, and intended to enhance learning, may have had the opposite effect. The nature of the text increased the number of pages and books; the fact that there seemed to be 'so much' study material may have increased anxiety regarding the amount of work that was required, and may have encouraged students to rush through the work rather than proceed slowly but more thoroughly. Furthermore, the need to cater for students who might not have studied mathematics beyond Grade 9 meant that the content covered a large number of concepts. Laurillard (1993) points out that when too much material is covered in a course, students rely on surface learning. There is a huge difference in the breadth and depth of study required by students from the two extremes: those having last studied mathematics in Grade 9, perhaps many years previously, and those having recently studied mathematics on Higher Grade in Grade 12. For the weak students the volume of work is greater than they are likely to manage. Should students who have not taken mathematics in Grade 12 be excluded from the module? Or would diagnostic assessment make it possible to determine which of the students who have limited mathematical background might be successful? The answer to this would require an analysis of the performance of Mathematics Access Module students who have only passed mathematics at the Grade 9[2] level, in the MDA and in the year-end examination.

Assessment methods changed with time. Could students learn from the assessment activities that were provided?

Formative assessment: Activities, exercises and assignments

The assessment activities, from the activities and self-assessed exercises in the study guides to the submitted assignments, seem also to have been of less benefit to students than was hoped. From discussions with students it appeared that time constraints dictated that after only limited attempts, if any, to solve problems in their study guides, they simply looked at the answers given and worked backwards to find out how the answer had been obtained. They were then not necessarily able to distil from this any specific problem-solving strategies, or any significant understanding of the concepts which the questions were intended to reinforce.

[2] Students selected their matriculation subjects at the end of Grade 9. These subjects usually remain the same in Grades 10, 11 and 12. It was thus uncommon for a student to have studied mathematics in Grade 10 or Grade 11, but not in Grade 12, hence the focus on Grade 9.

In the Mathematics Department appropriate external markers were carefully selected. On the whole the markers worked conscientiously, although from time to time problems arose in the level of commitment required to mark carefully, and in the extent to which markers could ascertain from a student's mistakes what the student's real problem was. In spite of careful and detailed marking, it seemed that many students did not pay much attention to the marked assignments or the printed solutions, but merely filed them to be used during examination preparation. This problem has been noted by tutors and lecturers, who are asked many more questions about the forthcoming assignment than about past assignments. It has also been evident later in the year. When students make appointments to discuss problems before examination time, they often demonstrate little awareness of the kinds of mistakes they had made in their assignments. Discussions with students suggest that in many cases they regard the assignments primarily as a means of obtaining credit, rather than as a learning opportunity. This is partly a result of the practice of having to qualify for examination admission by obtaining a specified number of credits.

The assignments were intended to reinforce concepts which would be the foundation for later concepts. Thus, missing out on the learning opportunity provided by one assignment undermined future learning. Apart from students not using the assignments as intended, it also later seemed that at times students were unable to make sense of the written comments on their assignments. In part this gave rise to the use of marking codes (see *Streamlining marking*). It is difficult to assess whether or not this had any impact on student understanding.

One limitation of the assignment system is that by the time marked assignments reach the students, they are already under pressure to submit other assignments, and they do not necessarily take time to learn from the marked assignments. In theory, markers are supposed to implement a two-week turnaround time, but in practice, when large numbers of assignments are submitted within a few days of a closing date, there is a bottleneck and the turnaround time is longer. The assignment solutions are posted automatically by the Despatch Department, on a date specified by the Mathematics Department. The marking of assignments is managed by the Mathematics Department, but the marked assignments are sent first to the Assignment Department for record-keeping purposes, and from there sent to students. Students thus receive the marked assignments and their solutions separately. If they do not then make a point of comparing their incorrect answers with the correct printed solutions, the impact is lost and a learning opportunity is missed.

On the whole, then, it would seem that students did not benefit significantly from the formative assessment tasks that were provided

Does the process of using assignment marks to qualify for examination admission have a negative impact?

It is evident from Table 8.4 that using the assignments as a means of qualifying for the examination had a marked effect. In 1999, 28% of the students who registered dropped out before the examinations, either because they had cancelled their registrations during the year, or did not obtain examination admission, or chose not to write the examination. Of the students who obtained examination admission, 152 did not write. Since credits required for examination admission were automatic if assignments were submitted, it seems possible that the large number of students who were admitted to the examination, but did not write, had underestimated the preparation required and had decided not to write. In 2000 the attrition rate was slightly lower (23%), and fewer students who could write elected not to do so (37 students). (See also Table 4.2.)

From 2001 onwards there was a continued decline in the relative number of students obtaining examination admission, and writing the examination. Although the required number of credits is 100, in practice even students with 90 and above credits are usually admitted to the examination. Students who obtain less than 90 credits are usually those who have submitted no or only a few assignments, those who have submitted them too late for the marks to be taken into account for credit purposes, or those who appear to have understood very little of the content of their study guides. In theory the assignments have fixed closing dates, to help students structure their studies. In practice the module leader makes allowances for late assignments: students are made aware of the need to post assignments early because of possible postal delays, but there is always a period of grace before the cut-off date for credit is imposed (usually about ten days after the stipulated closing date). The main point here is that out of approximately 260 possible credits, each year fewer and fewer students managed to obtain 90.

Can anything more meaningful be done to assist students to prepare for the examination?

In 2000, the 1999 examination paper was given as one of the assignments and was the only assignment for which credit was dependent on performance. This may have helped students to some extent prepare sooner and feel better equipped to tackle the examination, which might explain the increase in the pass rate in 2000. However, the pass rate decreased in 2001 even though much attention had been given to preparing students to tackle written questions, and to ensuring that the ‘mock’ examination and actual examinations were equivalent. The pass rate decreased again in 2002. The practice of using the previous year’s examination paper as one of the assignments was intended to be a way of helping students prepare for the examination, and of gauging whether the examination papers were of a similar standard. Since this was the case, it would seem unlikely that the decrease in the pass rate from 2001 to 2002 could be attributed to an increased level of difficulty in examination questions. It seems that without face-to-face interaction examination preparation seems to have had little impact.

More opportunities for contact were made available. Could students make optimal use of contact opportunities (such as appointments with lecturers)?

Increased opportunities for contact seemed to have achieved less than had been anticipated. Some students made an effort to contact academic staff (either speaking to tutors at tutorial classes, contacting lecturers by correspondence or e-mail, or making appointments to see lecturers) to discuss problems, which presumably resulted in greater learning, both in having to formulate and articulate specific questions, and in attempting to understand the necessary content and problem-solving strategies. Increased contact with academic staff did not appear to benefit a large number of students. From interaction with on-campus students it was evident that many students took advantage of the opportunity of regular personal tuition (making appointments to see lecturers on an almost weekly basis), but many of these students were still unable to pass. From discussions with academic staff who were available for student appointments, it also became increasingly evident that many students were unable to formulate questions. In the introductory letter they received on registration, containing general information relating to the module, students were told that simply stating a fact such as ‘I don’t understand inequalities’ was not helpful, and that they needed to be more specific regarding what was not clear, for example ‘In Book … when I read the solution to Activity … I could not understand why … .’ For many students their ability to communicate adequately in English limited the extent to which they could benefit from face-to-face sessions with lecturers. In such cases the informal peer-learning groups appeared to be effective in helping students find out together precisely what it was they did not understand; the spokesperson would then contact a lecturer, who could explain the problem to the group as a whole. This option was only available to on-campus students who were able to form such peer groups.

Although contact with lecturers became more readily available, it must also be borne in mind that many students who may have wanted to make contact may have been unable to do so. Transport is not always available and is costly; not all students have access to e-mail or telephone; many students have other commitments during working hours; the postal system in many areas is unreliable, and the time required for letters to reach lecturers, be answered and returned seems to have made letter writing a relatively little-used option.

The lecturers felt that the discussion classes were worthwhile, and students appeared to be grateful to be able to put a face to a name, and to have an opportunity to engage with mathematics in a more meaningful way. Interaction with students in discussion classes often acts as an 'icebreaker', and students then find it easier to contact the lecturer more often, to discuss problems. The fact that these classes were later only held in three centres (Pretoria, Polokwane and Durban) implies that the many students did not have the opportunity of attending such classes, and continued to work in isolation. Although it would have been helpful to establish whether there was any relationship between examination results and tutorial class attendance, at the time of writing the Department of Student Support was unable to provide the necessary data, even though tutors are encouraged to keep attendance registers. The premise is that students who make regular use of these tutorial sessions should perform better than others, in obtaining examination entrance, and in passing the examination, but it has not been possible to verify this.

10.3.2 The reading intervention

Phase III was the culmination of two previous interventions, and two associated research cycles. Reflection on these findings impacted upon the parallel set of research cycles relating to assessment, in that there was a greater awareness of reading-related problems during the process of scanning students' tasks to extract aspects that illustrated difficulties they were experiencing. Phase III was the only reading intervention implemented with the specific aim of improving the reading skills of a large number of Mathematics Access Module students, and it resulted in the production of a video, and the provision of a number of reading activities to gauge student competence with respect to reading and to reinforce the aspects of reading taught via the video.

Response to the video questionnaires was low. Although the majority of the students (those who responded to the questionnaires) perceived the video as helpful or very helpful, it did not appear to have helped them pass the final examination in 2002. However, there was some improvement in 2003. The number of students who submitted video evaluation questionnaires in 2002 and 2003 was low. The poor response possibly suggests a lack of interest, lack of access, or limited video usage which could be attributed to factors such as the increased volume of work or unfamiliarity with video as an educational medium. It is worth considering why many students did not return the questionnaire, and to what extent better research planning could have preempted this problem. Students possibly felt that the video was particularly unhelpful. They may also have attached a low priority on the need to comment. In some cases, students may have realised that they would not gain examination admission and thus lost interest. Students possibly just forgot to include the questionnaire with one of their assignments and did not wish to go to the extra expense of submitting it separately.

Analysis of the video evaluation results led to the conclusion that facilitated use of the video could possibly bring about greater benefits. Facilitation could take the form of human intervention in the form of additional tutors, but could also be built into the medium. Ultimately the use of CD rather than video may be more effective, as computer-mediated learning lends itself to higher levels of interaction than video. For example, when students are studying concepts that require discrimination of visible properties (for example graphs, geometric shapes), the easy access to comparisons made possible by multimedia is valuable (Laurillard, 1993). Using computers facilitates more immediate student action: the keyboard is physically more accessible than the buttons on a video cassette player, and students can be expected to respond to a greater number of commands. In a description relating to graphs, for example, a student can be asked to 'click on the point where $x > 0$ and $y \leq 0$'; failure to locate the correct point would automatically lead to a predetermined response.

Use of computers would require that students either have their own computers or access to computer facilities, such as the computers at the university's Learning Centres. The university continues to make provision for more such facilities in the Learning Centres, and hence, with time, this may become an option. If the video (or CD) could be optimally used, many of the problems raised by students in the questionnaires could be avoided, such as the false expectation that additional mathematics tuition should be provided, and problems linking video content with the study guides.

Tutors could assist in other ways as well. Students seem to regard 'the mathematics' as important and everything else as superfluous. If tutors were more actively involved they could assist by dispelling such myths. It has been a matter of concern that many Mathematics Access Module students have simultaneously studied the English Access Module, and yet their reading skills and language proficiency in the context of mathematics do not appear to improve. One possible reason for this was suggested by Grayson (1997): tutors and lecturers need to cue students to remember techniques learnt in one subject area, and apply them when appropriate in a new subject area. Academically immature students are unlikely to be able to do this for themselves. If English reading techniques or aspects of language structure seem to students to be unrelated to their mathematics texts, they may not apply what they in fact already know.

Increased tutor involvement could also lead to a more focused investigation into the helpfulness or otherwise of a video or CD approach to improving reading skills. Such an investigation would be more meaningful if both qualitative and quantitative aspects were considered. If the video was found to be beneficial, resources could profitably be allocated to making further adaptations and improvements. These ideas suggest a possible direction for future research.

10.3.3 Alternative assessment

The alternative assessment project was logistically demanding (too many assignments submitted, too little time in which to complete the marking and too few markers), and as such over-ambitious within the UNISA context. Although a project such as this may have had limited potential in the context in which it was used, its ultimate value was in the number of additional findings that emerged, namely the extent to which limited language proficiency, under-developed reading skills, inadequate general knowledge and poor meta-cognitive development may be undermining students' potential mathematical development.

Students' response to the project raises a number of questions. In some cases tentative answers are given; in others there do not seem to be any clear answers. If the research planning had included focus group interviews these may have been conducted to good effect. Consideration of small groups of students of different abilities from various backgrounds may have made it possible to determine more clearly whether the project assignment played any significant role in helping students engage with their study material by providing them with a creative and meaningful learning opportunity.

Was the project too ambitious?

Research has suggested that students' cognitive resources for problem solving are far weaker than it would appear from their performance on tests (Adams & Hamm, 2000). Schoenfeld has shown that even students who are mathematically talented have little awareness of how to use mathematical heuristics, and that students who achieved good grades frequently had many incorrect mathematical conceptions (Schoenfeld, 1992). Mason (2002) reflects on the tension between too great and too slight a challenge, and on the problems of achieving a balance between students' and lecturers' expectations. The project was thus perhaps pitched at a level at which too few problem-solving resources and too many misconceptions precluded success.

Is a project such as this feasible for large numbers of mathematics distance learners?

The experience described in Chapter 7 suggests it might be possible to make use of a project, provided a more practical marking system can be put in place. However, if several people were to be involved in the marking process, assessment criteria would need to be adjusted. With one marker eliminating subjectivity was straightforward; if more markers were to be simultaneously involved assessment criteria would have to be even more exact.

Is project work a valid way of assessing students from disadvantaged backgrounds?

It seems that the extent of the disadvantage cannot easily be determined, and that the background knowledge and academic and numerical skills of some students are so severely impaired, even in relation to access-level expectations, that it is impossible for these students to approach a project such as this with any chance of success. When an assessment method is selected it is important to consider not only the purpose of the assessment (e.g. formative, summative, diagnostic) and the cognitive skills to be assessed, but also issues such as the availability of resources and finances, and time constraints (Beevers & Paterson, 2002). It is true that 'Without equity in resources there can be no equity in assessment' (MSEB, 1993, p. 109). Did this play a role? The initial assumption that resources would be available to all students, from newspapers which could be borrowed to sophisticated computer databases, had seemed valid. However, home environments and student background may have played a role in limiting the extent to which such resources were accessible or acknowledged as sources of information on which a project could be based.

Laurillard (1993) has suggested that limited access to relevant material, equipment, or activities for study, such as scarcity of library resources, media resources and space, is a barrier to learning. Chapter 7 has suggested that limited general knowledge, brought about by limited access to rich sources of information in the home, may have led to some of the problems in performance in the project assignment. A study undertaken by Bernstein (Bernstein 1996, in Taylor, 1999) showed that learners who have been exposed to the kinds of conversations which occur in middle class homes and social circles, and have had access to books, computers, travel and other sources of information, have ready entry into the principles which underlie school (and by implication also university) knowledge. Education thus reinforces the codes which such learners bring to school. Those with impoverished backgrounds thus have less access to study opportunities, even when such opportunities are provided. Chapter 5 touched on the role that pleasure reading plays in developing reading skills fundamental to reading for the purpose of learning. The data obtained during Phase III of the reading intervention project (discussed in Chapter 6) showed how many students had limited access to books, with 29,9% claiming to have fewer than ten books in the home.

Do we know how much students learnt from doing the project?

The thinking processes students are expected to engage in when they tackle assessment tasks are as important as the content of assessment tasks (MSEB, 1993), and under the current conditions there seems to be no way of finding out anything about these thinking processes. This is a serious shortcoming, which deserves attention, but which can realistically only be investigated in a face-to-face context.

Is student confidence further eroded when they perform poorly?

There is no way to isolate this aspect of student learning from all others, but it may have been useful to conduct interviews with focus groups of students and assess their perceptions of the project, its effect on their confidence and the implications for learning. The comment of the disillusioned student noted earlier (A300: see 7.5.3) shows the possible seriousness of the consequences of assessment. Weaker students appear to have weaker meta-cognitive abilities, and many students were surprised by the fact that they had performed badly in the project. This may have led them to become discouraged and give up, particularly since they may have been hoping that the marks would contribute to their final marks, as well as to the credit total.

Does the disparity in performance of individual students in the two tasks (Task A and Task B), and the low correlation between student performance in the two tasks, suggest that different students respond more favourably to certain types of assessment than to others?

Good performance in real-life tasks and poor performance more abstract tasks, or the converse: which of the two is more indicative of students' understanding, mathematical proficiency, ability to think critically and analytically, and learn new mathematics? In the current assessment practices for the Mathematics Access Module no measures have been considered whereby different types of assessment tasks could be more meaningfully included, and students who perform well in certain types of activities may be at a disadvantage. The module outcomes require that students should learn to think analytically, demonstrate problem-solving ability, and work independently. If application and problem-solving are seen as important outcomes then it is important that these activities are not discontinued because some students have difficulty in coping with them, or because of logistical considerations.

Would the results have been any different if more support had been provided?

The more unprepared students are, the less capable they are of the autonomy required to tackle a project successfully. It was mentioned earlier (Rowntree, 1997) that projects may be a possible way of facilitating autonomous, independent learning; however, additional scaffolding may be necessary to assist academically unprepared students in reaching the required levels of autonomy and independence. Students may possibly be in a better position to undertake project work later in the year, after tackling additional preparatory activities.

Rowntree (1997) further suggested that while students are tackling a project support should be available, in the form of mentors or tutors who provide guidance regarding the manageability of the project in relation to the students' capabilities and circumstances, and who set deadlines for preliminary reports. He made the point that the assessment of the project 'needs to give as much weight to how [students] defined and set about their task and what they learned from it, as to the quality of their final report or presentation' (p. 96). Clearly this type of support is dependent on a significant degree of contact between students and tutors; however, one of the constraints of distance learning is that ongoing interaction with students is essentially limited. Support could include providing practice tasks in study guides; it could also take the form of tutor intervention. When learning is structured around enquiry (as in Task B) support from fellow students as well as from a tutor is seen to be important (Kahn, 2002). Considerable guidance would then be necessary to avoid the possibility of students 'sharing their ignorance'[3]. Mason (2002) suggests that formative assessment also occurs when, in the process of students constructing their own tasks, they are given the chance to submit initial drafts for comment before submitting a final version. Ideal levels of interaction are unlikely in the current UNISA context, but it is worth considering whether there may be ways of building in the required support.

[3] Not an original comment, but one overheard in a discussion; origin unknown.

To what extent do language and reading problems constitute significant barriers to success in tasks of this nature?

It seems that even though L2 students would have studied about half of their language skills[4] module by the time they tackled this project, very few of the language skills had been transferred to language-related mathematical tasks. The reading intervention (see Chapters 5 and 6) highlighted the impaired ability of many students to construct meaning from mathematical texts written in English. It thus seems feasible that language and reading levels should first be taken into account before considering a project such as this.

Can a project such as this be used to develop students' meta-cognitive skills?

It seems possible that student performance in the project was so dependent on existing meta-cognitive skills that success was unlikely unless a certain meta-cognitive 'threshold' had been reached. If this is the case it would be important to first assess meta-cognitive levels before exposing students to tasks in which they would be unlikely to succeed.

All these questions probably raise further questions, and highlight the need for a multi-faceted approach to assessment for Mathematics Access Module students.

10.3.4 Diagnostic assessment

At the 'Indaba' of Science, Engineering and Technology Foundation Programmes held at Wits in 2001 it clearly emerged that equity of access should be complemented by equity of outcomes. This has not been the case: disadvantaged (usually black) students have accounted for a larger proportion of drop out and failure than their white counterparts. Unless provision of access is accompanied by retention, access cannot be said to have taken place, and it is suggested that institutions 'do not recruit students who do not have the potential to pursue further study, and that they do not retain students who have no chance of success' (*Directory of Science, Engineering and Technology Foundation Programmes*, 2001, p. 219). Against a background of poor schooling and lack of opportunity, how can such student potential be determined, unless some form of diagnostic or placement assessment takes place? Such assessment should not be seen as a means of exclusion, but as a means of 'helping students make the right choices for themselves' (*Directory of Science, Engineering and Technology Foundation Programmes*, 2001, p. 220).

[4] Most L2 students studying the Mathematics Access Module were also registered for an English Access Module.

It seems that for a significant number of students there could be too big a gap between existing knowledge and academic skill at entry level, and the level at which the content and cognitive demands of the Mathematics Access Module are pitched. Under such circumstances there is no zone of proximal development in which learning can take place, and students cannot take advantage of the so-called opportunities for learning. The MDA was introduced in an attempt to address this problem.

Preliminary research with respect to the MDA suggests a number of aspects that should be further considered. In terms of the test, item-test correlations reveal a number of areas where further analysis of individual items, groups of items, category boundaries and weighting of questions would be useful. Many aspects of the results suggested additional analysis that could have taken place, but did not, as they had not been budgeted for (in terms of availability of staff and time to design and run additional programmes). In terms of the support, very little of the envisaged support materialised, and furthermore, no records were kept of incidences where students requested help. For high-risk students who choose to continue with their mathematics studies in spite of the risk, and for medium-risk students, it is essential that support is provided, coordinated and monitored.

It may have been interesting to consider whether the same risk categories would have been obtained if only the items with reasonably high item-test correlations had been taken into account, and to consider the impact of using only the ARC, or only the BAT, or specific combinations of ARC and BAT items, in the categorisation process.

It was pointed out earlier that on the whole the BAT items in January exhibited lower item-test correlations than the ARC items. It is important to ensure that all BAT items should accurately relate to overall quantitative reasoning skill. It may be the case that a number of items testing diverse skills may correlate better with the test if they are considered as a group, rather than separately. It might be helpful to give the BAT questions to a group of matriculants who have passed mathematics on Higher Grade. Such an exercise might also lead to a change in the weighting of some of the questions, and an analysis of the difference, if any, this makes.

The comparison of the results of the January group with their performance in the year-end examination, the results of the June group with their examination performance, and the performance of the January and June groups with one another will also yield interesting and potentially useful information.

There are still several difficulties that need to be overcome if diagnostic assessment is to become a meaningful practice at UNISA. The following questions need to be addressed.

What avenues are there for students in the high-risk category (Category 51) who wish to find help outside the university?

At other tertiary institutions students are sometimes not accepted, on the basis of their matriculation results or on the basis of placement testing prior to admission. Although UNISA would not reject anyone, students in Category 51 might experience a sense of rejection, and thus be dissatisfied with a university which creates the perception of being ‘open’ and hence raises expectations in the community that anyone can be admitted, whereas it would in fact be unlikely to have the resources to offer sufficient, meaningful support for such students. The possible options that may exist outside UNISA for such students need to be identified, so that students can be advised accordingly.

What are the psychological implications for medium-risk (Category 52) students of ‘going to university’ but needing to be taught again how to read?

Motivation is an important issue. What would keep the students involved in reading remediation? What immediately tangible incentives would there be to participate? Would medium-risk students have enough time for reading remediation and simultaneously for their academic studies? There are as yet no answers to these questions, and the matter needs to be further investigated. Further qualitative research needs to be undertaken.

From the university’s perspective, how will the necessary support activities be financed?

If students take the advice of the MDA and choose to defer their registration, how would UNISA generate funds to provide support for such students? Should students be required to pay for diagnostic assessment, or for subsequent support?

Answers to all these questions need to be found if the process of diagnostic assessment is to have value for the students and the university.

10.4 Limitations of the research

10.4.1 Parallel interventions

All research results relating to a particular intervention have been affected by the simultaneous exposure of the students to other interventions. Furthermore, there were ongoing attempts to improve teaching and support. Each intervention was thus in some way affected by factors related to the ongoing evolution of the module, quite apart from the effect of another intervention. Examination results may have been simultaneously affected by both interventions. The interpretation of the results of any intervention in relation to student pass rates should thus be viewed with caution. An attempt was made to separate the results in 2001, since Phase II of the reading intervention involved only a small number of students. The pass rate in 2001 may have been slightly inflated by the results of the students in the face-to-face reading intervention programme. It is reasonable that students who chose to participate in a voluntary reading intervention programme could have been expected to do better than their peers, as they may have had greater self motivation, and would certainly have had greater encouragement from the weekly contact sessions with the lecturers who were involved. However, if the results of these students are excluded, the pass rate becomes only marginally lower. Comparison of examination results and the assessment project results was possibly valid in 2001.

10.4.2 Time demands

The parallel sets of interventions and the increasing provision of support made significant demands on students' time. In 2002 more support than before had been provided, and two interventions were involved. In the case of the reading intervention, reading activities were incorporated in three of the assignments. For the assessment intervention students were expected to do both Task A and Task B. The pass rate was the lowest, and the attrition rate the highest, since 1998. Can we conclude from this that the support (in the form of a greater degree of teaching support, as well as exposure to two different interventions) itself took too much time, and left too little time for studying the mathematical content of the module?

It is possible to speculate that the aspects of reading skill assessed in the assignments in 2002 were too time consuming and discouraged students from submitting the assignments. Furthermore these sections, as poorly answered as they were, significantly reduced the percentages students obtained, and hence their credits. Although reading skills were not directly assessed in Assignments 1 and 3, about one quarter of the marks in Assignments 2, 4 and 5 related to reading issues, and this may have had a negative effect on the final mark obtained.

In 2003 the video had been improved and was shorter, and reading activities were incorporated in only one assignment. Regarding the assessment intervention, students were also expected to do both Task A and Task B. The impact of these changes could not be specifically measured.

10.4.3 Repeat students

The impact of the performance of repeat students on the results of any intervention was not taken into account. The results obtained in the third and fourth action research cycles associated with the reading intervention, and the results obtained in the second and third action research cycles associated with the assessment project, could have been skewed by the marks of students repeating the module. This factor was not taken into account in the analysis of the results. In the assessment project in particular it would have been particularly informative if the tasks of students repeating the module had been compared with their tasks in the previous year. This was not considered at the time.

10.4.4 Understanding the rationale for access to mathematics

The university generates subsidy through research and teaching credit-bearing modules, and many academics prefer to pursue their research interests rather than teach access-level modules. There is also (at certain levels) a perception that a tertiary institution should not accommodate students at this level, and that a dysfunctional secondary school system should not have to become the problem of the tertiary sector. In the NARSET Report (1997) Thijs asks whether the main reason for the provision of science (including mathematics) access programmes is the dysfunctioning of secondary education, or the need for tertiary science education to be transformed and restructured. Answers to this question will influence whether and how access opportunities (in both a broad and narrow sense) are presented in future. Central to this debate is the issue of whether access programmes should remain a temporary solution to a temporary problem, or whether they should develop into a structural component of the educational system (Thijs, 1997). No conscious attempt was made at UNISA to ask or address this question, whereas an answer in the early stages would have given greater direction to research activities that were undertaken. If any institution considers implementing similar interventions, or undertaking similar research, this question should first be addressed.

10.4.5 The changing South African Higher Education landscape

In Chapter 3 it was pointed out that the standard of the matriculation examination has fluctuated considerably during the period over which the interventions were implemented and associated research was undertaken. This suggests that analysis of results within a particular year may be meaningful, but that any attempt to compare results across the years may be problematic (although this has nevertheless been done).

10.4.6 Uncontrolled growth

In response to increased pressure to make tertiary-level mathematics accessible to large numbers of students who could not be accepted elsewhere, decisions were taken to admit students without due consideration of their potential to be successful, and without due consideration for the number of academic and other staff required to provide adequate levels of teaching and support if an open-door policy was followed. This inability to consider potential problems resulted in a *reactive development* process rather than a proactive approach: attempts were made to deal with problems as they arose, instead of taking time beforehand to learn from other access initiatives, and avoiding problems through careful research and planning. Creation of study material as a reaction to increased registration resulted in a module which focused mainly on content, and paid little attention to the context in which learning would take place. Considerable effort was invested in the development of study material, which is understandable, since the material is utilised by all registered students. The support initiatives, which could not reach all students, were well resourced, and the results show the effects of this imbalance.

The Mathematics Access Module has been strongly marketed as UNISA's answer to university entrance, or to the study of mathematics, for disadvantaged students. It seemed that the Marketing Departments have done an excellent job in attracting students, but that too many of the students were not adequately equipped for their studies. The Department of Mathematics had no control over student numbers, or over entry competence of incoming students. Rapid growth in numbers without concurrent growth in support was possibly partly responsible for the trend of low pass rate and high attrition rate.

The pressure of numbers impacted upon the research results obtained during each cycle. Comparison across the years of the results of larger numbers of less adequately prepared students may also have had an impact on the validity of the results obtained.

10.5 Directions for future research

In the mid eighties the creation of bridging, access, or foundation programmes that included mathematics was regarded as a short-term response to a problem that would not persist. Although the political climate has changed considerably since 1994, the problems related to education in general and mathematics education in particular have not yet been resolved. However, at UNISA it seems that the need for access to mathematics will continue to increase, rather than decrease. A number of aspects thus bear further investigation. Some of these have been discussed in relation to specific interventions earlier in this chapter, others are now considered.

10.5.1 Longitudinal research

The number of students who register for the Mathematics Access Module and either drop out or fail constitutes a waste of resources, which should not be allowed to continue. The impact of failure (failure to cope, as well as actual failure in an examination) on students with limited confidence, limited financial resources and few opportunities for becoming productive in a twenty first century environment, will probably be severe. Longitudinal studies of Mathematics Access Module students are essential in order to track students from entry to completion, and to investigate those who enter but drop out.

10.5.2 Formative assessment

As long as success is measured in terms of passing examinations, assessment issues necessarily assume great importance. It is thus important to investigate an optimal mix of assessment activities that could enable greater numbers of students to demonstrate what they know and can do, as was discussed in 10.3.3.

10.5.3 Academic support

Well-planned strategies for dealing with academic and quantitative literacy relevant to the study of mathematics need to be implemented on a wide scale, on the UNISA Main Campus and at all the Learning Centres. If this is done, well-planned research should be undertaken to investigate whether or not facilitated interventions with respect to academic and quantitative literacy can bring about improvement in mathematics performance

Some suggestions regarding aspects of the 2004 MDA results that require immediate investigation have already been made (see 10.3.4). Further analysis of the diagnostic assessment process in general is also necessary. It is important to consider what other data, such as school-leaving results, might compliment the student profile obtained from the assessment. If diagnostic assessment predicts student performance effectively it would be wise for the university to consider instituting assessment as a compulsory pre-registration requirement[5], rather than allowing simultaneous registration for the MDA and the Mathematics Access Module.

10.6 Conclusion

In Chapter 2 the point is made that one of the reasons for undertaking research such as the research described in this thesis should be to build on what has been done previously and share new insights. Some directions for future research arise from the insights given in this thesis.

Winter (1989, in McNiff, 2002) suggests a number of criteria for assessing action research reports. Reports should demonstrate six principles: Firstly a report should offer reflective critique in which the author shows that he/she has reflected on his/her work and generated new research questions. Secondly, the report should offer a dialectical critique which subjects all ‘given’ phenomena to critique, recognising their inherent tendency to change. Thirdly, the report should be a collaborative resource in which people act and learn as participants. Fourthly, the report should note that risks were taken, since risk is an inevitable aspect of creative practice. Fifthly the report should demonstrate a plural structure which accommodates a multiplicity of viewpoints. Finally, it should show the transformation and harmonious relationship between theory and practice.

In Chapter 3 it was pointed out that the research undertaken did not take the form of a participatory action research project. Winter’s third and fifth points thus do not apply in this case. However, there has been an attempt to generate new research questions; there has been some critique of the research undertaken; there has been reference to a number of constraints which reflect several risks associated with the research process and results; there have been links made between theory and practice.

Whitehead (2000) believes that action research reports can be judged in terms of whether the author shows that he/she is offering explanations rather than only observations and descriptions of practice. Where possible in this thesis explanations are provided, although observation and description of practice necessarily supported these explanations.

This research has focused on a particular module, the UNISA Mathematics Access Module. However, the results are generalisable to other similar mathematics modules, not necessarily in a

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[5] This was in fact accepted in 2005, for implementation in 2006.

distance-learning context.

In conclusion, these research results are offered as a basis for further research into the problem of providing access to mathematics for inadequately prepared students, in the interests of students, universities and the wider community. The research supports the point made at the beginning of this chapter: providing access implies not only the provision of content but also context: creating appropriate conditions for learning is as important as selecting relevant mathematical topics.