CHAPTER 4

CREATION OF A MATHEMATICS ACCESS MODULE:
STUDY MATERIAL, ASSESSMENT AND INITIAL SUPPORT OPTIONS

4.1 Introduction

At UNISA in the mid 1990s the focus was on creating access to mathematics, rather than providing access to any particular programme. In this chapter we move from a consideration of access to mathematics in general, to a focus on a specific UNISA module. For reference, the chronological development of the Mathematics Access Module is given. The process began with an examination only, leading later to the development of study material. As the focus shifted to the design of a specific module, a number of aspects needed to be considered, such as statutory requirements, characteristics of potential students, and curriculum requirements. In developing the material it was also necessary to consider appropriate philosophical and pedagogical perspectives, since these would influence the design of the study material. With the creation of study material, some forms of formative assessment and support also became possible.

4.1.1 Use of the term 'access'

Up to now we have in general been considering the broad problem of access to mathematics, in the sense of the different ways that institutions have attempted to bridge the gap in mathematical understanding, or to redress past inequities. The term 'access' now needs to be modified. From now on, it will be used in a narrower way to denote specifically the UNISA Mathematics Access Module, rather than the different types of programmes in existence designed to accommodate various groups of disadvantaged entry-level students. It was pointed out in Chapter 1 that the Access Module began as an access examination, and later developed into a taught module. The chronological development of the module is summarised in Table 4.1 on the following three pages, for reference purposes as the different aspects are described in the rest of this chapter.

Table 4.1:

Chronological development of the Mathematics Access Module study package[1]

Year	Study guides available	Additional study material	Exams (Type)	Lecturer contact	Tutorial classes	No. of assign-ments	Type of assignment	Max credits	No. of credits per assignment
1997	Book 0 of Bridging Module	**Tutorial letter**[2] One (Module information)	June, Oct (MCQs[3])	None	none	0			
1998	Book 0 of Bridging Module	**Tutorial Letter** One (Module information)	June, Oct (MCQs)	None	none	0			
1999	Books 1 to 5 of the Access Module, contained in tutorial letters; Book 6 published by UNISA under licence from the NEC[4]	**Tutorial Letters** 24 (Seven containing module information and assignment questions; twelve comprising the study guides in note form; five containing assignment solutions)	Oct (MCQs)	Limited: 2 lecturers to see students Discussion classes[5] in Pretoria, Durban, Cape Town	Pretoria Polokwane Johannesburg Cape Town Durban	5	MCQs	125	25 each, based on submission[6]
2000	Books 1 to 6 (complete books)	**Tutorial Letters** 12 (Six contained module information and assignment questions; five	Jan (supp) (MCQs) Oct (MCQs)	Limited: 3 lecturers to see students Discussion classes in Pretoria, Durban,	Pretoria Polokwane Johannesberg Cape Town Durban	5	MCQs Ass 5: 1999 examination paper	200	25 each for Ass. 1, 2, 3 & 4, based on submission Assignment 5: 100

[1] ‘Study package’ refers to all the components related to the module: the study guides, assignments, support initiatives, etc.
[2] At UNISA any printed correspondence directed to all students is referred to as a ‘tutorial letter’. Such letters may at times contain teaching relating to a particular aspect of a module, for example general feedback to assignments, where issues that appeared to be problematic for large numbers of students are addressed. These letters also contain general or administrative information, such as dates and venues of examinations, etc.
[3] MCQ: multiple choice question
[4] NEC: National Extension College, associated with the University of London.
[5] See Section 4.5.2.
[6] Credits based on submission imply automatic credit, regardless of quality of work.

		containing solutions for assignments; one containing a reading skills questionnaire)		Cape Town, Polokwane					
2001	Books 1 to 6	**Tutorial Letters** 15 (Nine containing module information and assignment questions and feedback for Assignments 1 and 2; five containing solutions for assignments; one containing the 'mock' exam paper)	Jan (supp) (MCQs) Oct (LMQs[7])	Limited: 3 lecturers to see students 3 external markers Discussion classes in Pretoria, Durban, Cape Town, Umtata Polokwane	Pretoria Polokwane Johannesberg Cape Town Durban Shingwedzi Umtata	6	No MCQs Ass. 3: special project Ass. 6: 2000 examination paper (self-assessed)	275	Assignments 1 & 2: 25 each, based on submission Ass. 3 & 4: 100 Assignment 5: 25
2002	Books 1 to 6 Book 7 (Video[8] workbook)	**Tutorial Letters** 17 (eleven containing module information and assignment questions, and feedback for Assignments 1, 2, 3 and 4: one of these included a video questionnaire; six containing solutions for assignments) **Video** ('Read to Learn Maths')	Jan (supp) (LMQs) Oct (LMQs)	5 lecturers to see students 3 lecturers to mark assignments 5 external markers Discussion classes in Pretoria, Durban, Polokwane, Umtata	Pretoria Polokwane Johannesberg Cape Town Durban Umtata Shingwedzi Worcester Stanger	6	As for 2001 (2001 examination paper self-assessed)	275	As above

[7] LMQ: lecturer-marked question
[8] The video and video workbook are explained in Chapter 6.

2003	Books 1 to 6 Book 7 (Video workbook)	**Tutorial Letters** 14 (Six containing module information and assignment questions, and feedback for Assignment 1, one containing the video questionnaire; seven containing solutions to assignments) **Video** ('Read to Learn Maths')	Jan (supp) (LMQs) Oct (LMQs)	5 lecturers to see students 3 lecturers to mark assignments 5 external markers Discussion classes in Pretoria, Durban Polokwane, Umtata	Pretoria Polokwane Johannesburg Cape Town Durban Umtata Shingwedzi Worcester Stanger	7	MCQs in Ass. 2, 4, 6 LMQs in Ass. 3, 5, 7 Ass. 3: special project Ass. 7: 2002 examination paper	260	Assignment 1: Part A: 25, for submission Part B: 25, based on mark Assignments 3, 5, 7: 50 Assignments 2, 4, 6: 20
2004	Books 1 to 6 Book 7 (Video workbook)	**Tutorial Letters** 13 (Six containing module information and assignment questions; seven containing solutions to assignments) **Video** ('Read to Learn Maths')	Jan (supp) (LMQs) Oct (LMQs)	5 lecturers to see students 3 lecturers to mark assignments 5 external markers Discussion classes in Pretoria, Durban Polokwane	Pretoria Polokwane Johannesburg Cape Town Durban, Umtata Shingwedzi Worcester Stanger	7	MCQs in Ass. 1, 2, 4, 6 LMQs in Ass. 3, 5, 7 Ass. 7: 2003 examination paper	260	Assignments. 1, 3, 5, 7: 20 Assignments 2, 4, 6: 60

4.1.2 Access examination as the first step

As was pointed out in Chapter 1, the Mathematics Access examination was the first step. This approach to the provision of access was maintained in 1997 and 1998. However, this did not provide sufficient numbers of students with access to the Science Faculty, as the pass rate was unacceptably low, as can be seen from Table 4.2.

Table 4.2:

Mathematics Access Module examination pass rates

Examination period	Registered	Admitted to examination	Wrote	Passed	Number passed/ number registered
Jan 1997	51	51	37	5	5/51 = 9,8%
Oct 1997	65	63	48	10	10/65 = 15,4%
May/Jun 1998	37	37	33	3	3/37 = 8,1%
Oct 1998	256	255	181	18	18/256 = 7,0%

4.1.3 The need for study material

Interaction between academic staff and students registered for the Mathematics Access examination was initially limited, but gradually increased. During 1997 and 1998 contact with these students suggested that they were unable to cope on their own. This was reflected in the low pass rate. The decision was made to provide a taught module, necessitating study material and support.

The problems experienced by Bridging Module students (see Figure 1.1 in Chapter 1: these students did not meet the entry requirement for mainstream mathematical modules) who were not coping with their studies gave further impetus to the development of study material at a lower level. At the time that the development of study material for the Mathematics Access Module was being considered, the entry requirements for the Bridging Module were matriculation exemption, and mathematics taken (but not necessarily passed) in Grade 12. Analysis[9] of Bridging Module examination results in 1996 and 1997 showed that students with matriculation exemption, but with mathematics marks of less than 40% on HG or less than 50% on SG, were unlikely to be successful in bridging the gap between secondary and tertiary mathematics, certainly in the space of one academic year[10]. At the end of 1997 a recommendation was made that such students needed additional preparation, for which study material was necessary. It was decided that such students should be required to pass the Mathematics Access Module before registering for the Bridging Module.

[9] The analysis was carried out by Carol Bohlmann and Joy Singleton.

[10] In the Science Faculty all modules extend over the academic year, and not over a semester (a semester extends over half an academic year). Registration at the end of February and examinations scheduled to take place from the middle of October leaves roughly seven to eight months of the year in which to study the module.

4.2 Factors to be considered before writing study material

4.2.1 Purpose of the module

The module was created to provide access to mathematics. It was established in an attempt to address the inequities of the past, and provide a 'second-chance' route into mathematics. It was important that the module would meet the needs of potential students and be acceptable to mathematicians and to the academic community.

4.2.2 Statutory requirements

The South African Qualifications Authority (SAQA) registers programmes on the National Qualification Framework (NQF) [11], which is an outcomes-based[12] framework for education and training standards and qualification. Various official documents[13] have shaped tertiary education policies, and in designing study material it was thus necessary to take official policy requirements into account as well.

4.2.3 Characteristics of the target student population

Student expectations and previous learning experiences, students' socio-economic circumstances and access to resources were additional factors that needed to be accommodated. Very few of these factors are individually identifiable, unless students inform lecturers or counselling staff about their circumstances. Several assumptions were thus made about the likely characteristics of the students for whom study material would be developed, based on the information outlined in Chapters 1 and 2.

There was considerable heterogeneity in the student group, with some students having recently taken HG mathematics in Grade 12 and failed it, and others having done no mathematics beyond Grade 9, long ago. Factors such as English language proficiency, literacy, learner motivation, background, etc., would significantly affect the attitudes and competencies of potential mathematics students.

It seemed reasonable to assume that the greater part of the student body would consist of matriculants from educationally disadvantaged backgrounds who wished to study at tertiary level, might have the potential to study science, engineering and technology subjects, but would not meet standard admission requirements. In certain cases it would also be necessary to accommodate students from other countries where the school-leaving qualifications were not adequate to guarantee acceptance into the first year of a degree in South Africa. Mature students who wished to change direction, or

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[11] The Mathematics Access Module is listed as a SAQA level-4 module.
[12] See Appendix A for an outline of the tenets of Outcomes-Based Education (OBE) in South Africa.
[13] Such as the SAQA Act (Act 58 of 1995), National Standards Body (NSB) Regulations (Reg. 452, No. 18787: March 1998) and Education and Training Quality Assurance (ETQA) Regulations (Reg. 1127, No. 19231: September 1998)

were first-time entrants to university, would also need to be accommodated. (See *Directory of Science, Engineering and Technology Foundation Programmes*, 2001.)

In the design and implementation of the study material for the module it was thus necessary to create material that would meet the needs of a mathematically and culturally diverse spectrum of students, young and mature, L1 and L2, without being patronising, and simultaneously without giving offence.

4.3 Issues in setting up the curriculum

All curriculum decisions were left to the two lecturers responsible for writing the study material. Critical decisions regarding what to include and what to exclude had to be made. This reflects one of the dilemmas of curriculum planning:

> … not everything that is worth knowing can be taught; not everything that can be taught is worth knowing; and there is still not enough time for everything at the intersection of what can be taught and what is worth knowing (Secada & Berman, 1996, p. 28).

The syllabus for the Mathematics Access Module appears in Appendix B. The content was selected in accordance with what students could realistically be expected to know and do when they began studying, and what they would be required to know and do by the time they had passed the module. This, in turn, was related to the requirements of the programmes students could be expected to follow after completion of the module.

Discussions were held with academics in the Departments of Physics, Chemistry, Statistics and Computer Science, as well as with academics in the different Life Science subjects, to form an idea of which mathematical concepts were essential, and which could be excluded. The Mathematics Access Module was designed to prepare students to study mathematics at the level of the Bridging Module. It also needed to prepare students to move on to Life Science courses without the need to take further mathematics modules. These students would need a working knowledge of exponential and logarithmic functions, particularly the natural exponential and natural logarithmic functions. The module also needed to provide a solid foundation for other Natural Science subjects. In addition to preparing students for further mathematics and for other sciences, it was also important that the Access Module should have inherent value in terms of providing a sufficient level of numerical competence for everyday living. Certain assumptions needed to be made about students' content knowledge, which influenced decisions regarding the concepts which needed to be explained in considerable detail, and those which could be assumed to be common knowledge.

Around the world at the time that study material was being developed there was increasing concern to have a ‘strong’ mathematics programme in schools, as advocated by Usiskin (1999). In the early 1990s many governments, including the South African government, advocated such a curriculum; in addition there appeared to be general international agreement on the essentials of such a curriculum (Volmink, 1999). Although UNISA is a tertiary institution, there was clearly a need to address first what should have been dealt with at school. The curriculum requirements, together with the short academic year, led to the decision to address some, but not all, of the issues fundamental to a ‘strong’ mathematics. The components of such a programme include basic skills, conceptual understanding, numeracy, meaningful mathematics, creativity, positive disposition, reasoning, representation and modelling, communication, application, social development, cultural context, integration of technology, and general mathematics literacy (Usiskin, 1999). Some of these aspects are mathematical, while others are social or personal; some of the mathematical aspects also have social or personal implications.

Social and personal aspects

For the Mathematics Access Module some of the social or personal aspects could only be touched on briefly, such as the need for a ‘positive disposition’, which is discussed in the first study guide (Book 1[14]: Introduction). At this point students are encouraged to try to ignore previous learning experiences that may have affected them negatively, and have an open-minded approach to the Access Module material and a new study opportunity. In an attempt to provide guidance regarding subject-specific academic skills, several pages in Book 1 are devoted to study skills that are important in mathematics, such as the importance of self-discipline, perseverance, regular practice, etc.

Mathematical aspects

In a strong programme there is emphasis on learning and understanding, on the connectivity of ideas, incorporating number concepts, algebra, geometry, measurement, statistics and elementary probability. English (2002) stated that

> Today’s mathematics curricula must broaden their goals to include key concepts and processes that will maximise students’ opportunities for success in the 21st century. These include, among others statistical reasoning, probability, algebraic thinking, mathematical modelling, visualizing, problem solving and posing, number sense, and dealing with technological change (p. 8).

[14] In this chapter, and the rest of the thesis, references to Books 1, 2, 3 etc. of the study material relate to the 2000 edition of the books written by Singleton & Bohlmann. The books and their titles are listed in the Reference section at the end.

Certain mathematical aspects of the so-called strong programme could not be dealt with, as the means to do so were not necessarily accessible to all students, such as the use of technology. Limited previous mathematical exposure, general knowledge and an understanding of basic mathematical concepts meant that modelling could not be addressed, except in a superficial way, for example in modelling the exponential growth of the HIV/AIDS virus (Book 3, pp. 311 – 312).

In attempting to address basic skills, numeracy and general mathematics literacy, it was important to pay attention to the mathematical concepts that are necessary for everyday living, such as concepts of numbers, decimals and fractions, ratios and percentages, and basic statistical concepts, in order to correctly interpret numerical and statistical information in newspapers or other media. If students do not understand percentages they cannot understand interest rates; if they do not understand decimals they cannot quickly and easily make calculations with money; if they do not understand how to estimate they will not have a sense of a bill being incorrect; if they do not understand ratios they will be unable to compare costs of products in a meaningful way. Students' social development is thus linked to the mathematics they study.

At an access level it may be difficult to convince students that the mathematics they are studying is meaningful and relevant. The relevance of everyday concepts such as area and volume may be obvious, but where the content becomes more abstract (for example when abstract concepts such as functions are involved) it is harder for students to grasp its relevance. However, it was decided that the inclusion of simple real-life examples, with sufficient explanation of the relevant theoretical aspects, would enable students to extrapolate the relevance of more abstract mathematics. For example, the path of a projectile could be used to illustrate parabolas, and provide a window on the relevance of other aspects of quadratic functions, even though the theory was beyond the scope of the Access Module.

Usiskin (1999) and English (2002) suggest that creativity and the mathematical thinking processes associated with modelling are important aspects of a meaningful curriculum. Creativity is difficult to generate when there are limited concepts with which to be creative, although it is important if students are to become innovative and independent.

A meaningful curriculum emphasises mathematical thinking processes such as visualisation, pattern recognition, conjecture, generalisation and representation, integration and synthesis (see for example Schoenfeld, 1992). An understanding of sequences, for example, is dependent on recognising pattern.

Once the content had been selected in broad terms, it had to be divided into a number of different topics. The specific outcomes for each topic had to be clearly established, so that the assessment methods could focus on the stated outcomes[15]. Many mathematics textbooks pitched at the introductory level were consulted in order to form an overview of the philosophical and pedagogical approach, style and contexts other authors had used, and the types of problems that were included. For example, Fleming, 1989: *Precalculus Mathematics: a problem-solving approach*; Ruud & Shell, 1990: *Prelude to Calculus*; Petocz, 1992: *Introductory Mathematics*; Lial, Miller & Hornsby, 1993: *College Algebra* (6th edition); Stewart, Redlin & Watson, 1993: *Mathematics for Calculus* (2nd edition); Poole, 1994: *Basic Mathematics*; Freeman, 1994: *How to Learn Maths*; Cook, 1995: *Introductory Mathematics*; Smith, 1996: *Agnesi to Zeno*; and Movshovitz-Hadar & Webb, 1998: *One Equals Zero and Other Mathematical Surprises: Paradoxes, Fallacies and Mind Bogglers*.

The material was written during 1998 and 1999. There were six study guides, called Books 1 to 6. Books 1 to 5 were written by lecturers in the Mathematics Department. The sixth study guide (Book 6) was a book called *How to Learn Maths* (Freeman, 1994), published by the National Extension College (NEC), part of the University of London's International Extension College. The book did not cover all aspects of the syllabus, but it provided a useful overview of many concepts, and was simply and clearly written. Several sections of the book were ideally suited to the needs of Access Module students, particularly the section dealing with the subtraction of negative integers. Rather than write a book that simply duplicated another it was agreed[16] that UNISA could print the book locally under licence[17]. It was included in the study package students received, from 1999 until 2003 (at no extra cost to students). Figure 4.1 shows the study guides that were initially available. Apart from Book 6, which was referred to in all other books, students needed to progress sequentially through the study guides, from Book 1 to Book 5.

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[15] During the first phase of writing, the outcomes were identified, but not specified as such in the study guides. They were stated in 'Checklists' at the ends of topics, as a reference for students: a quick way of assessing what they knew, and what they would still need to study. In the 2004 editions of the guides the outcomes were stated upfront, so that students knew in advance exactly what was expected of them.
[16] At first the NEC suggested that UNISA students should buy the book directly from them, but logistical and cost considerations led to the negotiation of a licence agreement between UNISA and the NEC.
[17] With the weakening of the South African currency, particularly towards the end of 2001 and during 2002, these costs were becoming prohibitive. In 2002 it was decided that since the study material was to be revised in 2003, the authors would incorporate additional explanations or examples in Books 1 to 5, where applicable, so that the *How to Learn Maths* book could be phased out, as from 2004.

Figure 4.1:

Study Guides for the Mathematics Access Module

Developed at UNISA	**Printed under licence by UNISA**
Book 1 Introduction ↓ **Book 2** Number Skills & Algebra Tools ↓ **Book 3** More Algebra Tools ↓ **Book 4** Graphs & Statistics ↓ **Book 5** Geometry & the Measurement of Areas and Volumes	**Book 6** How to Learn Maths

4.4 Development of the study guides

4.4.1 Starting point

From the introduction of the Bridging Module in 1993, data was gathered to assess student perception of the study material (which consisted of five study guides and an audio cassette), the support available (viz. the provision of tutorial classes and lecturer assistance by correspondence or by contact if required and possible), and the assignment system, whereby students were required to submit written assignments, for which a correction-marking system[18] was in operation. Analysis of this data was begun in 1996 and completed in 2000 (Bohlmann, 2001). Many of the findings were relevant and applicable to the Access Module, and could be incorporated during the final stages of development in 2000, such as the use of examples and activities, and a similar layout and writing style. In 1999 the Access Module study guides were made available in the form of several sets of notes, and not in a consolidated, bound, book format. The first complete set of study guides (books) was produced towards the end of 1999 and early in 2000. These books remained in use until the end of 2003. The

[18] In a correction-marking system students submit an assignment, which is then reviewed by a lecturer, or an external marker. For questions that are totally or almost totally correct, marks are awarded. Where questions contain errors, either in mathematical concepts, or in the use of appropriate notation or presentation, comments are written to guide the students in correcting these questions. The assignment is then submitted again, and marks are then given for questions to which marks were not previously allocated. Lack of staff dictated that this system would not be implemented for the Mathematics Access Module.

guides were revised and adapted in 2003, for use in the subsequent three-year cycle (2004 to 2006).

Many excellent textbooks were available, and it would have been possible to use one of these, and write additional notes where necessary. The Bureau for University Teaching (BUT[19]) advised the authors that L2 students may have problems with textbooks because of the relatively terse writing style and dense text. The decision was thus made to write study guides that would be more suited to the students' requirements.

4.4.2 Philosophical approach

Emphasis on understanding

In all the attempts to reform American secondary education standards (beginning with the National Council of Teachers of Mathematics (NCTM) Curriculum and Evaluation Standards for School Mathematics in 1989) the central tenets have continued to emphasise understanding over memorisation, to promote active learning, and to focus on problem solving (NCTM, 2000). This approach to teaching was also evident elsewhere, for example in the Realistic Mathematics Education movement in The Netherlands (see de Lange, 1987). Even & Tirosh (2002) refer to the seminal work done by Skemp in 1978, in which the distinction is made between two kinds of understanding in mathematics, namely relational understanding (knowing what to do and why) and instrumental understanding (applying rules without necessarily knowing the reasons). However, it is also important to keep in mind (see Nesher, 1986, and Resnick & Ford, 1981, in Even & Tirosh, 2002) that teaching for understanding without sufficient attention to algorithmic and procedural aspects is questionable, since memorisation of certain facts and procedures is important as a way of extending working memory capacity and facilitating 'automaticity of response' (p. 224).

To try to ensure that real learning would take place, transferable to new contexts, it was necessary to ensure that the integrity of the discipline would be maintained, i.e. there would be no 'watering down' of content or explanation that would satisfy short-term goals but might compromise long-term understanding (in a relational sense). The underlying philosophy in developing all the material was that teaching should focus on helping students to understand *why*, and not just *how*.

For example, achieving conceptual understanding of the process of cancelling fractions (based on understanding the concept of factors) makes it easier for students to understand simplification of algebraic expressions later. There is more to persuading students to use an algorithm appropriately than simply demonstrating how to carry out the different steps of the procedure and providing practice

[19] Later called the Bureau for Learning Development (BLD).

opportunities (Orton, 1994). Providing a clear explanation of the algorithm for cancelling would facilitate mindful abstraction of the principles which could then later be applied in a different context (simplification of algebraic fractions), i.e. the so-called ‘high-road transfer’ described by Salomen & Perkins (1989). For example, it is important that students should understand why

$$\frac{2+3}{3}=\frac{5}{3} \text{ and } \frac{2}{3}\times\frac{3}{5}=\frac{2}{5}$$

are correct, and why the following two statements are incorrect:

$\frac{2+3}{3}=2$ (by simply crossing out the 3s)

$\frac{2+3}{3}=3$ (if they ‘cancelled’ to obtain $\frac{2+1}{1}=\frac{3}{1}$).

‘Reform’ vs. ‘traditional’ approach

In the early 1990s, mathematics curriculum development in South Africa was still being influenced by the debate surrounding the respective merits of the traditional and reform views of mathematics teaching. These two perspectives, often regarded as being in opposition to each other, provoked considerable discussion in mathematics education, and continue to do so. (See for example references to the ‘math wars’, and the impact of traditional and reform approaches on student learning, Boaler, 2002.) It is clear though, that ‘Without the distorting lense of ideology … most of the stated ideas are not contradictory at all, but complementary’ (Goldin, 2002). For example, skills and reasoning are not opposites, but each involves the other; similarly, expository teaching and guided discovery need not be contradictory, and the philosophy underpinning the development of the Access Module study material took both views into account. The debate regarding the traditional and the reform views of mathematics education focused on the respective merits of an abstract approach to teaching as against a contextual approach. For the Access Module it was decided that as far as possible the content would be related to contexts that would be familiar to students. However, even though relevance to real-life issues is important, it is also true that so-called real-life contexts are not necessarily accessible to all students, for many different reasons (Murray, 2003). For example, students who have not been to schools with adequately equipped science laboratories may not understand explanations of volume involving pipettes or burettes. It was also recognised that although contextualised representations help students up to a certain point, they need to make the cognitive leap to an abstract situation in order to make progress. One of the significant problems of mathematics distance learning is that there is little opportunity for monitoring individual student readiness to progress from concrete to abstract: the abstract representation is introduced at a particular point in the study material and students may simply continue reading, and not reflect on the shift of perspective. This suggests that the study material needs to minimise opportunities for misunderstanding by making the links between concrete and abstract as clear as possible.

Individual construction of knowledge

Building on the work of Piaget, van Glaserfeld (1991, in Orton, 1994) emphasised the importance of limiting the transfer of 'ready-made' knowledge, and the need for students to be actively involved in the process of constructing their own knowledge. While this may be valid, even in face-to-face teaching contexts 'activity' does not always imply creative mental activity (Orton, 1994). In a mathematical context constructivism suggests the importance of students making sense of new concepts for themselves, and not merely accepting statements as 'ready-made' truths. This poses a dilemma for distance education in that the provision of activities which students may engage in, in order to build up and make sense of concepts in their own minds, does not ensure that students will use the activities as intended. Although printed study material on its own cannot rule out such potential difficulties, it was decided to write the study material in a way that would lead students as far as possible to the discovery of important mathematical concepts and not merely present concepts as sets of facts or rules.

Interactive approach

The quality of interaction between students and the learning environment will have an effect on the quality of the learning (Orton, 1994). The term 'interaction' is readily understood in a face-to-face context, but has many different implications for distance learning. In print-based distance learning the study material is essentially 'pre-packaged' with the inherent danger that this format ignores the dynamic nature of learning. One way of overcoming this danger is by ensuring that the materials are used together with explanatory feedback, i.e. that there is some two-way communication (Garrison, 1995). With respect to the Mathematics Access Module material, two-way feedback required the introduction of assignments. By means of this feedback learning becomes more interactive and hence more effective, since, as Garrison puts it, 'A primary purpose of education is to have students (re)construct events and ideas, while avoiding being trapped by their own unchallenged interpretations' (p. 137).

The trade-off

From the foregoing discussion it is clear that any design decisions would involve a trade-off between the reality and the ideal. Teaching for understanding implies that study material would build from simple to cognitively more demanding concepts, providing students with some opportunity to apply concepts in solving problems. Procedural understanding was emphasised as a vehicle, and not as a goal in itself. This approach would benefit in particular students who would later continue with mathematics courses. It was however possible that the focus on understanding might not appeal to students with no intention of continuing with mathematics. A developmental approach to facilitating conceptual understanding increases the number of pages provided, and students with very weak background knowledge are then given more than they can manage and may consequently learn less, as they are intimidated by the amount of material they need to process. The design of study material thus needed to aim for a balance: enough to facilitate conceptual growth; not too much so as to be unmanageable.

It is accepted that in general rote learning should be avoided. However, it is also true that many people (including mathematicians) have on occasion learnt aspects of mathematics in this way without fully understanding at the time, and only understood later, after much practice. On the other hand there are others who have rejected mathematics because they did not understand enough, and had 'too little in the way of connections between networks in the mind' (Orton, 1994, p. 48). The design of the study material thus assumed that in some cases full understanding would not be achieved immediately, but frequent use and application of concepts would lead to understanding at a later stage.

A constructivist approach may be effective in cases where a teacher or some competent facilitator is available to guide students appropriately. In distance learning it is also possible for students to interact with their lecturers via the assignments and various other means and learn from their mistakes; they can work through their study guides and achieve adequate levels of conceptual growth which would enable them to solve problems set in assignments and in an examination. However, this ideal may not always be realised.

If we consider a 'worst-case scenario': students with virtually no existing mathematical skills or competence, and little environmental support, with limited English language proficiency and reading skills, and limited exposure to scientific aspects of the real world, would be expected to work through six or seven study guides, on their own, with limited support from the university. Students with limited financial resources register as late as possible, thereby shortening even further the academic 'year'; academic immaturity and lack of study skills would encourage a surface approach to learning which would militate against discovering mathematical concepts and against problem solving.

4.4.3 Pedagogical approach

The philosophical perspective within which the material was developed influenced the pedagogical approach. Furthermore, the decision to promote positive learning styles and to provide support for learning within the text, was important in formulating an appropriate pedagogical approach. The selected pedagogical approach also needed to be relevant and accessible to the target population.

Student diversity

The multicultural and multilingual context dictated that the pedagogical approach should accommodate students' cultural environments and levels of linguistic competence. In attempting to accommodate students from diverse cultural backgrounds, it is important to remember that 'there is no such thing as culture-free "best practice" in mathematics teaching' (Clements & Ellerton, 1996, p. 34). The mathematical content should thus be linked with other curriculum areas and aspects of the students' lives, on an ongoing basis.

Surface and deep learning

Many students could be expected to enter university with ineffective learning styles, favouring rote learning and a surface approach, acquiring 'quantity without quality' (Ramsden, 1992, p. 45). A more effective approach favours deep learning, in which students seek to understand concepts and make connections between them (Kahn, 2002). Past experience has shaped students' attitudes to learning mathematics, and has often led them to believe that it is difficult, cannot be understood, and must be memorised. If the study guides could promote understanding, perceptions could possibly be changed, so that ultimately students could appreciate that a deep approach is essential for further conceptual development. Mindful of the fact that many students had not developed appropriate study skills, some guidance with respect to the specific academic skills that are required to learn mathematics was also provided (in particular in Book 1).

Scaffolding

Distance learning in particular requires some form of scaffolding, and study material is often characterised by in-text activities (see for example Lockwood, 1995; Rowntree, 1997). Activities refer to questions or other tasks integrated into the teaching material, with encouragement for the student to answer a question, or carry out an investigation, before referring to the answers or results provided in the study material. In printed distance-education materials the solutions for activities are sometimes placed immediately after the activity; sometimes at the end of a section, to limit the tendency of students to continue reading without doing the activity. The solution to each of the questions is comprehensively set out, so that the students can 'see' how the task is carried out 'by a competent practitioner' (Hauser, 2002, p. 38). Lester (1980, in Frobisher, 1994) claims that 'It also seems obvious that the likelihood of improved problem-solving performance is increased if students see good problem-solving behaviour exhibited by their teacher' (p. 167). In-text activities include examples, and students are expected to work through all the steps. Examples provide additional explanation or clarification of concepts, and usually precede activities.

The use of examples and activities was also influenced by the results obtained in a number of studies relating to schema acquisition, rule automation and cognitive load (see for example Sweller, 1989; Sweller 1994; Mousavi, Low & Sweller, 1995). Sweller (1989, 1994) paid considerable attention to the relationship between schema acquisition and rule automation, and learning and transfer. Schema theory (the generalised description of several problems and their solutions) and the automation of problem-solving rules are important aspects of mathematical learning and are prerequisites for the transfer of knowledge and skills to a new domain (low-road and high-road transfer (Salomen & Perkins, 1989)). A schema is a 'cognitive construct that organizes the elements of information according to the manner with which they will be dealt' (Sweller, 1994, p. 296; see also Orton, 1994). In other words, schemas allow problems to be classified into categories according to the way in which they may be solved. Schemas increase the amount of information that can be held in working memory, in the same way that although the number of words on a page may exceed working memory, the number of ideas or concepts probably do not. Not only do schemas organise items that must be learnt, but once they have become acquired and automated they themselves become elements in higher order schemas (Sweller, 1994). Working through examples and activities assists students in the acquisition of appropriate schemas and in the development of problem-solving strategies.

As we have seen, in-text activities may be helpful; however, they should not impose too great a cognitive load. The cognitive load imposed by instructional material can be attributed to the inherent complexity of the concepts, but it is also a function of the cognitive activities required of students by the manner in which the information is presented. Mathematics is a conceptually complex discipline with a high level of element interactivity (Sweller, 1994). In other words, each specific concept consists of a number of inter-connected concepts, and cannot be learnt unless the separate elements and the connections between them are learnt. For example, in order to solve the equation

$a/b = c$ for a, i.e. to find that $a = bc$;

students may have learnt that

a/b can be multiplied by b to give ab/b; c can be multiplied by b to give bc;

they may also have learnt that

in the expression *ab/b* the *b* may be cancelled out so that $ab/b = a$;

they may also have learnt the rubric that

anything done to one side of an equation must also be done to the other side.

The procedures used in each one of these steps can be learnt in isolation, and the tasks involved in each step do not interact, i.e. there is a low level of element interactivity. However, at the point where students need to know that in order to solve the equation they must multiply both sides of the equation by the denominator on the left in order to isolate the numerator on the left, the elements assume a higher level of interactivity. A high level of element interactivity is characteristic of concepts that cannot be grasped unless they are understood. This is certainly true of mathematics, and instruction should be carefully designed to facilitate this process.

The use of activities and examples is also in line with Vygotsky's notion of the Zone of Proximal Development (ZPD). The ZPD is defined as the distance between the student's actual level of development, and the potential level of development that could be reached with the assistance of someone more capable (in terms of knowledge and experience) (Vygotsky, 1978; Greenes, 1995). In distance learning 'someone more capable' would be the lecturers, expressing themselves via the study guides, and later via the assessment tasks provided.

4.4.4 The end result

All the aspects above played a role in the design of Access Module study material. Assumptions about students' backgrounds influenced the kinds of activities and examples that were used to illustrate concepts. Activities and worked examples were used to illustrate concepts, and exercises were provided within each section, so that the concepts learnt in that section could be specifically practised. The solutions of activities and examples explained step-by-step how the answers were obtained. For convenience the solution of each activity was placed immediately after it, but the students were encouraged to try to solve the problem on their own before reading the solution. A simple concept could thus be presented, that could reasonably be expected to be familiar to all students. This concept could then be extended by means of leading questions, illustrated by means of examples, progressing to relevant activities with solutions, to help students reach an understanding of some new concept. The following fraction example illustrates this approach. (See Book 2, pp. 99 – 101.)

In the section dealing with fractions, the sub-heading 'Dividing Fractions' is given. It is introduced by referring students to a previous study unit in which division of integers is discussed; there is a margin note[20] carrying the important reminder that

$$a \div b = a \times \frac{1}{b}, b \neq 0$$

Since formal proof is beyond the scope of the module, but the rules of division need to be established, the following example is given (also as a margin note).

We can see intuitively that this rule is valid for all real numbers. Suppose we have three apples. How many halves can we cut from these three apples? Obviously we will have six halves, i.e.

$$3 \div \frac{1}{2} = 3 \times \frac{2}{1} = 6\ .$$

The rules that relate multiplication and division of integers (explained in detail in an earlier section of the study guide) are then discussed in relation to rational numbers, with a reminder that division by zero is undefined. Words that might be problematic (invert, reciprocal) are explained in margin notes. An example is then given:

Calculate

(a) $\frac{3}{5} \div \frac{7}{10}$ (b) $\frac{3}{4} \div (\frac{1}{6} + \frac{7}{8})$

In both cases, each step of the solution shows why a particular procedure is applicable. The example is followed by an activity:

(a) Why does the number zero not have a reciprocal?

(b) Calculate $\frac{3}{4} \div (\frac{1}{3} ! \frac{5}{6})$.

For (a) students need to have learnt the meaning of reciprocal and taken into account that division by zero is undefined. The second part (b) involves division of a fraction by the difference of two fractions, and as such is very similar to the second question in the example provided. Students are

[20] Margin notes are explained in ‘text organisation’ a little later in this section.

expected to try to carry out the activity on their own first, and then compare their answers to the solution provided. The solution is again detailed, showing all steps, even though in practice it would be simple to consolidate several of the given steps into one. Additional examples (becoming progressively harder, involving other aspects of operations with fractions) and activities follow. Exercises at the end of the section contain further questions, answers for which are given at the end of the book. Now, to assist students who may have difficulty with terminology, particularly L2 students, further scaffolding is provided at different points in the text in the form of 'Ways with Words' blocks[21] which clarifying the meanings of various terms. An example is given in Figure 4.2.

Figure 4.2:
Ways with words

Not knowing 'how to say something' can get in the way when we try to work with the 'something'. This may be a problem in the case of fractions.

Number as the denominator	What we call the fraction	Example
2	half (plural: halves)	1/2: one half
3	third	2/3: two thirds
4	quarter or fourth	7/4: seven quarters
5	fifth	3/5: three fifths
6	sixth	1/6: one sixth
…	…	…
20	twentieth	11/20: eleven twentieths
…	…	…
100	hundredth	1/100: one hundreth
and so on	…	…

Problem solving

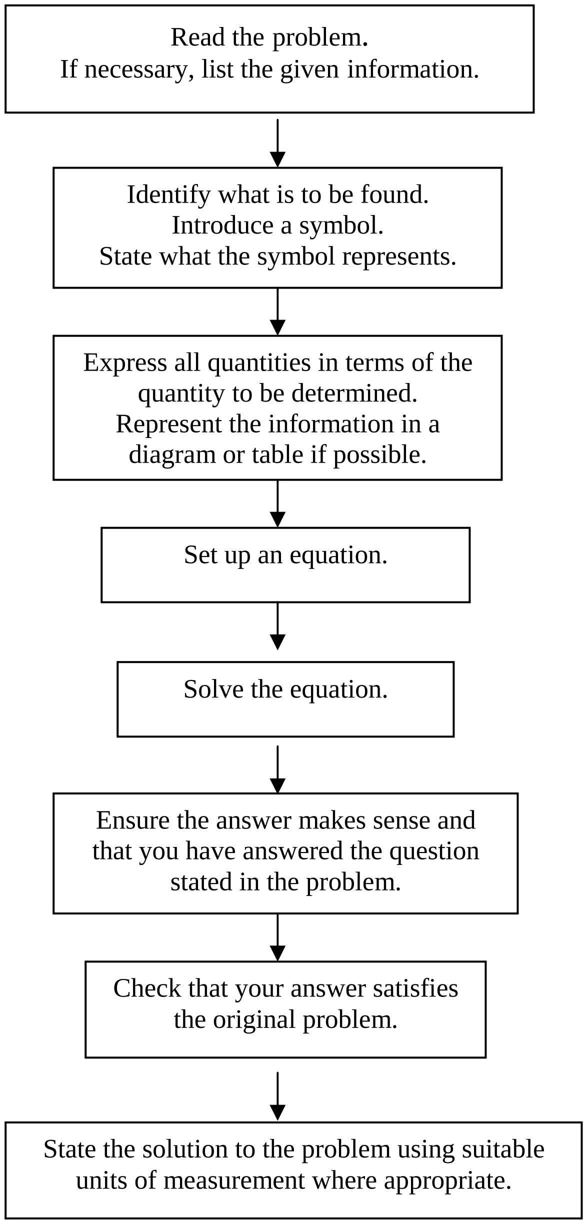
The philosophical approach, with its emphasis on understanding, meant that problem-solving skills needed to be addressed. The use of diagrams to provide contextual support in problem solving is an

[21] The block shown here appears differently in the study guides. All topic headings, activities, examples, 'ways with words', etc. are denoted by means of specific icons. These take up a large amount of space, and have not been included here.

important adjunct to problem solving. In Book 3, for example, students are given a diagram to help them formulate mathematical equations and solve problems. See Figure 4.3 (Book 3, p. 83).

Figure 4.3:

Problem solving activities



A number of examples are given in which students are shown how to apply this table in solving different problems.

Organisation of text

Physical aspects such as the organisation and presentation of the content are important factors which also need to be taken into account. The mental processes engaged in learning, understanding and applying complex concepts impose considerable cognitive load. It is clear that the study material should not itself impose additional unnecessary cognitive load.

Cognitive load may be reduced by avoiding the 'split-attention' effect. This occurs when learners need to divide their attention among and mentally integrate various different sources of information (Sweller, 1994; Mousavi, Low & Sweller, 1995). The principle of reducing cognitive load by limiting the split-attention effect was one of the factors which influenced the decision to produce study material for the Access Module rather than use a textbook: split attention is reduced when the material is in a 'stand-alone' format (i.e. not in a 'wrap-around' format, which would require students to switch frequently between the textbook and other study material).

Where conceptual misconceptions could be expected, which would require students to find appropriate explanations, the split-attention effect is limited by including margin notes at relevant points, such as in the example given earlier. Margin notes may help to reduce the split-attention effect in several ways. Firstly, by *reassuring* students, so that attention is not diverted by anxiety: for example, in Book 4, p. 163, direct proportion is illustrated using Hooke's Law. The margin note states: 'You do not need to have studied the concepts that we use from physics, chemistry, etc. We use them to show you further applications of straight lines.' They can be used to *facilitate recall* so that there is no need to page back and look for the relevant section: for example in Book 4, p. 120, there is the following reminder. 'Remember: Horizontal lines have slope 0 and vertical lines have no slope, and we deal with them separately. Horizontal and vertical lines are perpendicular to each other.' Margin notes can provide *additional mathematical explanation* to eliminate confusion: for example in Book 4, pp. 147 - 148, there is a discussion on finding the vertical distance between two lines. One of the margin notes on p. 148 provides additional explanation on the importance of knowing which point lies directly above/below another, so that subtraction can be carried out in the correct order. These notes can also provide *additional language clarification* where necessary: For L2 students, even though the language used should be as straightforward as possible, it is clearly impossible to identify every possibly unfamiliar word. However, it is possible to help students with some of the everyday English words that have a different meaning in mathematics, as well as with certain other confusing aspects of the language (for example pointing out the importance of prepositions, in phrases such as 'divide by', or 'divide into' (see Book 2, p. 59). Language matters could be dealt with by referring students to appropriate sources of information, but it is possible that the link with the mathematics would not be made. To avoid the split-attention effect that this would involve, the problem is dealt with at the point where the words are first used. Various ‘Ways with Words’ items, such as the example given earlier, were introduced at relevant points to deal with anticipated problems.

In designing study material it was necessary to organise the text carefully to reduce cognitive load, thereby facilitating learning. A number of factors are involved in such ‘careful organisation’ of teaching material. The writing style should be such that it encourages students, with possibly limited exposure to books and limited confidence, to engage with the mathematical concepts. Such a ‘user-friendly’ approach requires that attention be given to certain physical features of the material: cognitive load was limited by reducing text density (i.e. the number of words per page was kept low, with plenty of ‘white space’), important rules and definitions were boxed, and sentence and paragraph length were kept to manageable proportions. The text was divided into manageable chunks by breaking up the topics into sections, and dividing these in turn into smaller study units. Text organisation was facilitated by means of so-called reader stoppers, i.e. icons that indicate logical breaks in the text. A variety of textual support mechanisms were included to facilitate learning, such as the use of Outcomes (in the second edition of the study material) to give students an overview of what they would be learning. Mason (2002) suggests that students may find it difficult to follow the intention of a topic that is presented without having the lecturer’s perspective on what the purpose of the topic is, and how it fits into the rest of the material. Checklists and Summaries were provided to facilitate the review process, in which students were encouraged to reflect on what they were supposed to have learnt. Various ‘Useful Hints’ were included at times to clarify concepts. For example, the following two hints are provided in the introduction to function notation (Book 4, p. 69).

> $f(x)$ **does not mean** $f \times x$. The notation $f(x)$ refers to the **value** in the range associated with the domain element x. If the ordered pairs (x, y) are elements of f then we write
>
> $y = f(x) = \ldots$ some rule (such as an equation) which tells us what to do with x in order to obtain y.
>
> Hence $f(x)$ is the value of y for some $x \in D_f$. If x is an element of the domain of f, then $f(x)$ is an element of the range of f.

$f(x)$ is not the function f. The function f is the set of all ordered pairs (x, y) or $(x, f(x))$ in $\mathbb{R} \times \mathbb{R}$, whereas $f(x)$ is a single number in $\mathbb{R}$.

Remember:

$$f(x) \in \mathbb{R}$$

$$f \subseteq \mathbb{R} \times \mathbb{R}$$

$$f(x) \neq f.$$

Apart from the physical organisation of the text, the linguistic and contextual demands also need to be taken into account. One of the SAQA outcomes (see Appendix C) is effective communication. In mathematics this includes communication in terms of the discourse of the discipline. Students need to be encouraged to present their work in mathematically acceptable ways, i.e. to make sure that what they write down can be ‘read’ and makes sense. During the writing of study material attention was given to clear presentation of content, and mathematical activities were explicitly presented in a way that could illustrate what is meant by ‘mathematically acceptable presentation’.

The trade-off

There was also an inevitable trade-off in terms of the pedagogical approach. The notion of scaffolding together with fading (see Mason, 2002) is difficult to implement in a distance-teaching environment, as there is no way of knowing whether students are ready for explicit guidance to be reduced, on the assumption that they may have reached a stage where they spontaneously know what is expected. Consequently, there is no fading in the study material, and the pedagogical approach is consistently supportive throughout, possibly to the detriment of students who may need to adopt a more autonomous approach in later modules.

Completing a prescribed chunk of content is hardly compatible with constructivist views of learning (Orton, 1994). There is thus a tension between covering the required content within a specified time, and providing students with the freedom to develop understanding at their own pace, in their own way.

If on the one hand it is accepted that a deep approach to learning is preferable to a surface approach, and on the other hand that students may well favour a surface approach or rote learning, how can ineffective learning styles be changed? How can students be persuaded that a deep approach is essential to understanding the content, particularly when the study guides are the main means of communication? In an environment where time constraints, limited opportunity for contact and support, and other factors exert significant pressure, the reality is that the majority of students will probably continue to favour a surface approach, as a survival tactic. However, since an effective approach to learning is an important outcome in its own right, it is important to recognise that ‘we are not trying to change students, but to change the students’ experiences, perceptions, or conceptions of something’ (Ramsden, 1992, p. 45). The study material thus provides frequent encouragement to students to reflect, make sure they have understood, and review previous sections where necessary.

4.5 Assessment and support

Different forms of formative assessment and increasing forms of support were introduced with time, and will be discussed in more detail in Chapter 8. In the beginning both formative assessment and support were available to a limited extent only.

4.5.1 Assessment

The philosophical and pedagogical approach, as well as a number of practical factors, affected the nature of the formative assessment tasks. Once study material had been introduced it was possible to set assignments. Assignments were thus introduced in 1999. Assignments provided an opportunity for formative assessment, with questions based on the content of the study guides. Initially the assignments consisted of computer-marked multiple-choice questions only. Given the hierarchical and cumulative nature of mathematics, understanding of new concepts depends on the level of comprehension of previous concepts. The activities and examples in the different sections, and to some extent the exercises at the end of each section, aim to consolidate concepts learnt in separate sections (facilitating schema acquisition and automation), but there is little opportunity to integrate across topics, and apply, for example, algebraic principles to a geometry problem. Assignments aim to synthesise and consolidate across topics, in line with assessment hierarchies noted earlier (see 2.3.2, in Chapter 2).

Apart from formative assessment, opportunities for self-assessment were also provided. In designing the study guides it was important to aim for a balance between reading and doing, and intersperse learning with assessment tasks, such as the exercises. A too heavy reading load, for example long stretches of just reading explanations, is likely to cause a survival mentality, leading students to become surface processors, just to ‘get by’. In the design of the study material it was decided that opportunities for self-assessment would be built in to the different topics. Exercises were provided at the end of every section. To assist students in the self-assessment process, answers for the problems set in each study guide were given at the end of that guide. In some cases only answers were given; in other cases more detailed solutions were provided.

Assignments also serve to create a balance between reading and doing, but it is important that the assessment load is not too heavy, so that students attend to assessment matters only (Marland, Patching, Putt & Putt, 1990). Turn-around times, postal constraints and the length of an academic year affect the provision of opportunities for meaningful assessment. Again, a balance needs to be found between 'enough' and 'too much' from the perspective of students, academic staff and logistical requirements.

Summative assessment, in the form of examinations, took place at the end of the academic year. Since the assignment questions were in MCQ format, the examination questions followed the same format.

4.5.2 Provision of support

Contact with lecturers

Towards the end of 1998 students had begun to visit the Mathematics Department more frequently to ask for help with their studies. From the beginning of 1999 the two lecturers who had written the study guides began actively teaching the module, i.e. they set assignments and were available to see students and answer queries.

Further contact with lecturers was also possible through discussion classes, which were introduced in 1999, and have continued since then. The term 'discussion class' refers to a two-day visit by a lecturer from the Department of Mathematics to one of the regional centres where large numbers of Access Module students are enrolled. On each of the two days the lecturer spends three hours with the students who attend, and deals with problems students raise, as well as with specific problems the lecturer wishes to discuss.

Contact with tutors

Additional funding of the Mathematics Access Module by the university in 1999 made it possible to offer tutorial classes at a number of Learning Centres across the country. Affording Access Module students the opportunity of attending such classes is important, especially for students who cannot meet regularly on campus. These classes give them the chance to meet other students, with similar circumstances and similar problems, and help them to find their feet in the foreign environment of distance learning. Tutors are not expected to lecture, but to facilitate learning. Observing a tutor engaging with mathematics problems helps students grasp that the solutions to mathematics problems are not envisaged in their entirety (i.e. as one complete piece of mathematics) at the outset, but solved by step-by-step application of carefully considered procedures, which do not always yield the right answer, or any answer, immediately (see for example Frobisher, 1994; Mason, 2002). Mason makes the point that being seeing ‘someone struggling publicly can be of real benefit to students who have the mistaken impression that mathematics springs from the pens of experts fully formed like a textbook’ (p. 100). Students who are never exposed to this process may remain at a disadvantage.

The Department of Student Support (DSS) is informed by the Learning Centres when more than five students at a given Learning Centre are interested in mathematics tutorial classes. This necessarily only takes place after the close of registration (end of February) so that tutors may only be appointed by the end of March. The tutoring period thus usually extends from April to just before the examinations are written. The DSS provides the Department of Mathematics with the curriculum vitae of possible tutors, and the Department of Mathematics selects suitable tutors, who are then appointed by the DSS. Tutors are provided with training in generic skills by the DSS, and given all academic material required for the module they will be tutoring. Tutors communicate with the Department of Mathematics via the departmental Tutor Coordinator and the module leader. The module leader for the Access Module provides subject-specific guidance, such as topics that may need additional attention, appropriate pace at which students should be working, problems with assignments, etc.

Students pay the Learning Centre a nominal fee to attend tutorial classes: this one-off annual fee entitles a student to attend tutorial classes for a maximum of three modules for which he/she is registered. However, this fee and the transport costs involved may make it impossible for some students to attend. Class length and frequency depend largely on availability of venues at suitable times; however many tutors exceed class length and provide extra help for individual students before or after the official tutoring period. Since students often arrive at tutorial classes with limited understanding of the work they have been expected to prepare, tutors are often required to teach the work scheduled for the session, rather than answer questions and help students solve problems.

Students are encouraged to attend tutorial classes as regularly as possible. Tutors have reported (for example at departmental tutor workshops) a variety of problems that affect the success of the tutorial classes, namely initial enthusiastic enrolment followed by early drop out and poor attendance. Tutors need to cope with diverse needs and abilities in the tutorial groups. Tutors play a valuable role in providing the module leader with useful information, such as students' attitudes to the module and the assignments or problems that the lecturers may not be aware of regarding content, levels of student effort and workload. Interaction between lecturers and tutors helps to motivate tutors. By sharing problems they become aware of similar problems experienced by other tutors, and they obtain additional guidance regarding effective tutoring techniques. This is especially helpful for inexperienced tutors.

Initially (in 1999) tutorial classes were provided at the Learning Centres in Pretoria, Johannesburg, Pietersburg (now called Polokwane), Cape Town and Durban.

4.6 Results

As a result of low pass rates, the introduction of the Mathematics Access examination failed to achieve its purpose, namely to increase access to other university mathematics modules, such as the Mathematics Bridging Module. Study material was thus written and some formative assessment and support were provided to try to improve matters. The philosophical and pedagogical approaches selected in the design of the Mathematics Access Module were chosen with the background and characteristics of the target student group in mind. With the introduction of study material in 1999 enrolment increased significantly. Although the pass rate increased it was still low; furthermore, a large number of students did not write the examination. See Table 4.3.

Table 4.3:
Mathematics Access Module results in 1999

Examination period	Registered	Wrote	Number passed	Number passed/ number registered	Number passed/ number wrote
Oct 1999	799	575	122	122/729 = 15%	122/575 = 21%
Jan 2000 (Supplementary[22])		58	19		
Consolidated (Oct & Jan)			141	141/799 = 17,6%	141/575 = 24,5%

It appeared from assignment marks and interviews with students that they were finding it difficult to engage with their study material and to relate it to everyday situations. Feedback obtained during face-to-face sessions with students and tutor reports identified students' approach, both to their assignments and to their study guides, as a significant problem. It appeared that students often tackled

[22] Students were admitted to the supplementary examination if they had failed the examination at the end of the year (i.e. obtained less than 50%), but had obtained 45% or more. The supplementary examinations also served as aegrotat examinations

assignments without necessarily trying to understand the concepts involved (for example by simply trying to find a similar example and adapt it to the assignment question), without trying to make sense of their answers and without paying much attention to the way answers were presented. As one of the markers commented ‘These students have never expected anyone to read their written explanations: only answers matter.’

It also seemed to be the case that students viewed the written sections of their study guides as irrelevant: they seemed to want to skim over the text, and focus only on the ‘mathematical’ sections. In some cases it seemed that this might be the result of a misconception regarding what constitutes mathematics. In other cases it seemed that the students were having difficulty processing what they were reading.

4.7 Summary

This chapter discusses the evolution of the Mathematics Access Module out of the Mathematics Access examination. It focuses on the design and development of the study material for the module, and the initial provision of some formative assessment and support. Poor results led to a consideration of potential underlying causes, such as the possible barrier created by weak reading skills, and limited ability to engage effectively with the study material provided. As a result of these concerns it was decided to consider an alternative approach to assessment. It was also decided to investigate students’ reading abilities, and try to determine whether, and to what extent, reading skill was related to mathematical performance. This decision led to the first cycle in each of the two sets of action research cycles described in Chapter 3. Chapters 5 and 6 describe the steps involved in investigating the role of reading in relation to mathematics, and Chapter 6 deals with the alternative assessment project.