CHAPTER 3

RESEARCH DESIGN

Chapter 3 outlines the research method used in this study.

3.1 A two-phase process

When the decision was made to increase access to mathematics at UNISA there was no conscious attempt to frame the activities in terms of research. However, as the initial attempt at opening up access was extended, and additional aspects were involved, certain results emerged which needed to be investigated. There are thus two phases that are considered in this thesis. The first phase was a pre-research phase, and the second phase involved a number of action research cycles.

3.1.1 Pre-research phase

The pre-research phase began in 1998, when a Mathematics Access examination was introduced. From the beginning of 1999 study material, assessment and support were available in varying degrees. All aspects involved were informed by research, but no systematic study of these aspects was undertaken. However, a number of aspects emerged which required attention, and the decision was made to investigate systematically two particular aspects, namely students' reading skills, and an alternative approach to assessment.

3.1.2 Access to mathematics in an action research framework

Although the research was not initially conceptualised within an action research framework, the investigations into reading and assessment stimulated two sets of cycles involving problem identification, plans to address the problem, intervention phase, reflection on the outcome, modification of the plans, etc. These processes are characteristic of action research. This chapter now considers the theoretical aspects of action research as well as its relevance to the reading and assessment interventions that were undertaken.

3.2 Description of action research

Action research has been described as a 'small-scale intervention in the functioning of the real world and a close examination of the effects of such an intervention' (Cohen & Manion, 1995, p. 186). It has also been described as 'a particular way of researching your own learning' (McNiff, 2002, p. 15). Zuber-Skerrit presented a CRASP model for action research (Zuber-Skerrit, 1992, in McNiff, 2002, p. 51). In her definition action research could be seen as

Critical (and self-critical) collaborative enquiry by

Reflective practitioners being

> **A**ccountable and making the results of their enquiry public,
> **S**elf-evaluating their practice and engaged in
> **P**articipative problem-solving and continuing professional development.

Macintyre gives the following definition:

> Action research is an investigation, where, as a result of rigorous self-appraisal of current practice, the researcher focuses on a 'problem' (or a topic or an issue which needs to be explained), and on the basis of information (about the up-to-date state of the art, about the people who will be involved and about the context), plans, implements, then evaluates an action then draws conclusions on the basis of the findings (Macintyre, 1991, in Macintyre, 2000, p. 1)

By 'up-to-date state of the art' the author implies that the choice of the topic, and possible ways of investigating the topic, should be informed by recent literature. After considering a number of ways in which action research could be conceptualised, McNiff concludes that it is 'a spontaneous, self-recreating system of enquiry' (McNiff, 2002, p. 56).

If one of the tenets of action research is that it should be undertaken in order to improve practice, some evidence would need to be provided to show in what way the practice has improved, and by what criteria this claim is made (McNiff, 2002). Under these conditions action research can be seen as a

> disciplined enquiry, where a practitioner systematically investigates how to improve practice and how to produce evidence for the critical scrutiny of others to show how the practice can be judged to have improved (McNiff, 2002, p.103).

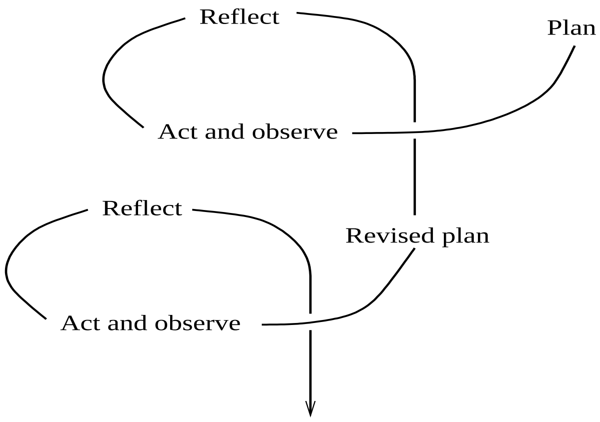
Cohen & Manion (1995) give a number of characteristics that usually apply to action research. Action research involves diagnosing a problem in a particular context and trying to solve it in that context; it is often collaborative, involving a team of researchers and practitioners; it may be participatory, with the team members taking part directly or indirectly in the implementation of the research; and it is self-evaluative: modifications are continuously evaluated within the research context. Cohen & Manion also suggest two specific stages within which action research takes place: a diagnostic stage during which problems may be analysed and hypotheses developed, and a 'therapeutic stage, in which the hypotheses are tested by a consciously directed change experiment' (p. 186).

A fundamental purpose of action research is thus to augment the practitioner's functional knowledge of the phenomena involved. McNiff (2002) emphasises the self-evaluative nature of action research: 'it involves you thinking carefully about what you are doing, so it can be called a kind of self-reflective practice. … Action research involves learning in and through action and reflection' (p. 16). Action research can be undertaken for different reasons and in many different contexts, where it is recognised that innovation and change may be required, and opportunities envisaged in which innovation or change may be implemented. Sagor (2000) claims that the primary reason for doing action research is to improve or refine practice. Clearly then, action research could be undertaken to improve a given situation, by 'injecting additional or innovatory approaches … into an ongoing system'; a potential difficulty being that the ongoing nature of the context in which the research is to be conducted 'normally inhibits innovation and change' (Cohen & Manion, 1995, p. 189). McNiff (2002) sees the main purpose of action research to be the generation of knowledge which leads to improved understanding and experience, for the benefit of a particular community, often an educational one. When action research is undertaken within an educational context, it should also contribute to 'a theory of education and teaching which is accessible to other teachers' (Stenhouse, 1979, in Cohen & Manion, 1995, p. 186).

In general, action research relies mainly on observation and behavioural data, and can thus be aligned with both qualitative and quantitative methods. In action research, the term data is usually understood to mean information (McNiff, 2002). However, at times quantitative methods are involved in an analysis of quantitative data, although not in the sense of a rigorously controlled experimental model, in which specific variables are separately analysed, and the results compared against those of control groups. The data that is collected is not necessarily representative; interpretive analysis of restricted data may not be generalisable. A distinguishing feature of action research is that it is empirical, i.e. 'over the period of a project information is collected, shared, discussed, recorded in some way, evaluated and acted upon' (Cohen & Manion, 1995, p. 192). These activities form the basis of reviews; feedback can then be translated into modifications and may then give rise to a new sequence of activities, with the aim of bringing about 'lasting benefit to the ongoing process itself rather than to some future occasion' (p. 192). More than half a century ago Lewin developed a theory of action research involving an action-reflection cycle of planning, acting, observing and reflecting (Lewin, 1946, in McNiff, 2002). Carr and Kemnis (1986) promoted the idea of 'educational action research' (Carr & Kemmis, in McNiff, 2002, p. 45); together with McTaggart, Kemmis proposed a spiral model to illustrate the activities that the researcher undertakes in the process of taking action to improve an educational situation (Kemmis & McTaggart, 1988, in McNiff, 2002, p. 46). Figure 3.1 illustrates the sequence of spiralling action-reflection cycles that are involved.

Figure 3.1:

Sequences of action-reflection cycles



McNiff's idea of the spontaneity of action research suggests that although the notion of a systematic process of observe, describe, plan, act, reflect, evaluate and modify may be theoretically acceptable, in reality 'it is possible to begin at one place and end up somewhere entirely unexpected' (McNiff, 2002, p. 56).

An action research project would usually progress through a number of stages (see Cohen & Manion, 1995, and McNiff, 2002). The first stage comprises the identification, evaluation and formulation of the problem requiring investigation, involving also a review of current practice and an identification of what could be improved. The second stage involves preliminary discussion and negotiation among those who have an interest in the matter, where a way forward may be imagined. This stage may result in the formulation of a proposal as to what might be done. The third stage may involve a review of relevant research literature; this may lead to a fourth stage: a modification of the initial formulation of the problem, or to a modification of the proposal. The fifth stage could involve the choice of research strategies; this would give rise to the sixth stage, namely the selection of evaluation procedures. The seventh stage involves the implementation of a particular intervention, and includes important practical aspects such as conditions and methods of data collection, monitoring of tasks and data analysis. The final stage is the interpretation of the data, a taking stock of what has happened as a result of the activities/interventions that were implemented, and decisions regarding the outcome of the project. These decisions may result in the modification of the original plans, and the creation of a new action phase, which would then proceed through similar stages.

3.3 Research method used

In general action research is applicable whenever ‘specific knowledge is required for a specific problem in a specific situation; or when a new approach is to be grafted onto an existing system’ (Cohen & Manion, 1995, p. 194). In such a case a planning stage must be followed by some action suited to the particular context; the action needs to be observed; there must be reflection on the process, which may possibly lead to a new cycle. For the research to be successful, ‘suitable mechanisms must be available for monitoring progress and for translating feedback into the ongoing system’ (Cohen & Manion, 1995, p. 194). The method is thus applicable in situations where teaching methods, learning strategies, and assessment practices are to be investigated.

The research described in this chapter is a modification of a standard action research design. It consisted of two parallel sets of action research cycles, running concurrently. In some years the cycles involved all students; at other times one of the cycles involved only a small group of students. The cycles all ran for a full academic year; in some cases significant modifications took place, in other cases there were only minor modifications. Figure 3.2 shows the different cycles, and the periods over which they were implemented. It also reflects a possible advantage of having two parallel sets of cycles: at times results in one cycle had some impact on an aspect of the other set of cycles.

From a research design point of view it would have been preferable to implement only one intervention at a time, and study it thoroughly. However, no specific resources were available for research activities, which then happened as a result of other factors. A colleague in the Department of Linguistics had obtained funding for reading research; she had obtained interesting results in other disciplines and was interested in following up on discussions regarding the possibility of limited reading skills undermining student performance in mathematics. Her research funds thus made it possible to follow that strand of the research, beginning towards the end of 2000. The assessment intervention began in 2001, but had already been planned in 2000, as the UNISA scheduling process requires all assignments for each year to be submitted by the middle of the previous year. This gave rise to the situation in which two interventions were conducted simultaneously. The availability of short-term outside funding[1] at this time also made it expedient to carry out the interventions in parallel.

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

The action research method is relevant to the development of access to mathematics at UNISA for several reasons. One of the main reasons supporting the use of action research is improvement of practice (Cohen & Manion, 1995, p. 192). At UNISA the research process began when it became clear that a particular situation, namely provision of access to mathematics for a specific group of students, needed to be improved. In 1999 it was evident that the introduction of study material and some support was not producing the desired results. In the UNISA context, the researcher played the role of researcher, course developer and teacher simultaneously. McNiff (2002) alludes to Chomsky's notion that it is possible to be both practitioner and researcher, and that the practitioner's form of theory should not 'be regarded as practical problem-solving rather than proper research' (Chomsky[2], in McNiff, 2002, p. 20). It should be noted that the action research processes described did not involve participatory action research: the students provided the context in which the research was carried out, but were not participants in the research process; other academics cooperated with the researcher in conducting the research but were not themselves participants in the activities being researched.

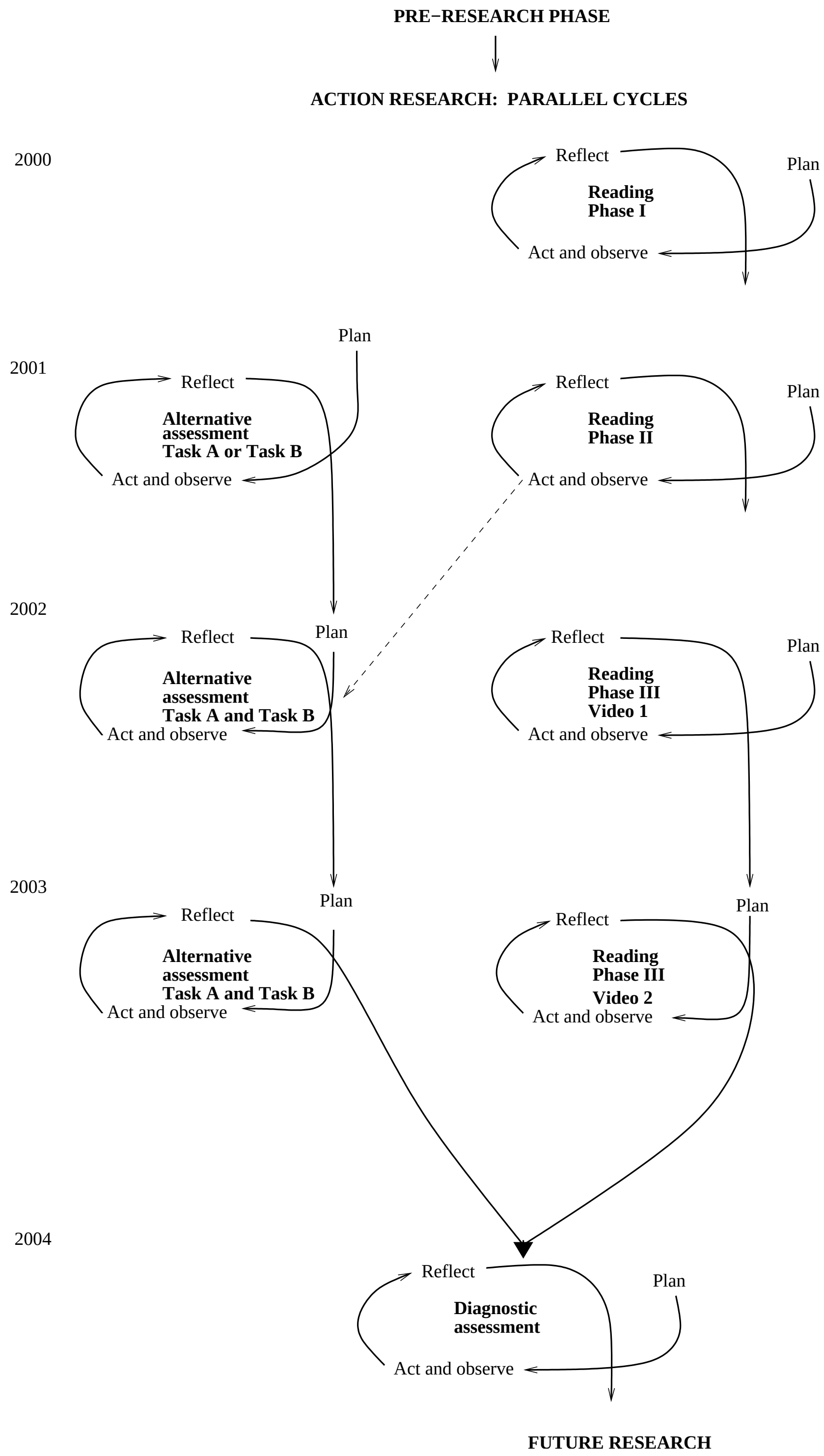
The process of creating access to mathematics at UNISA has been a dynamic one, and many investigations were carried out during the process of adapting different initiatives, over time, to accommodate perceived student needs. Figure 3.2 shows the cyclical nature of theory-based reflection leading to interventions aimed at improving opportunities for access to mathematics, and research on the effects of these interventions. The figure also shows that there were several cycles in the two parallel sets.

The process began with the pre-research phase of course development and associated teaching, where the author of the study material was also involved in teaching the students for whom the material was designed. During the teaching process, a number of problem areas emerged, requiring further investigation. The author/teacher then assumed the role of researcher, and research into several relevant aspects led to the introduction of two interventions, designed and implemented by the author/teacher/researcher. This process was cyclical, as can be seen from Figure 3.2 and from the overview of the thesis given at the end of the first chapter.

[2] Several references to Chomsky's works are given in McNiff's book, but it is not clear in which of these references this aspect is addressed.

Figure 3.2:

Mathematics access initiatives – an action research framework



The two sets of action research cycles focused on reading skill in relation to mathematics learning, and on assessment. The two sets evolved in tandem with one another, but will be described separately below.

The process began in 2000, with the initial investigation into students' reading skills. This investigation (referred to as Phase I of the reading intervention) reached a fairly large number of students but was purely an exploratory process, and was not expected to have any impact on students' learning, or examination results. Results of the test were however compared with examination results. This action research cycle led to Phase II, in 2001. The second action research cycle involved the implementation of a face-to-face reading intervention programme and an analysis of its impact. Phases I and II are described in Chapter 5. Analysis of these results led to the final phase in the reading intervention, namely Phase III, which commenced in 2002, but extended to the end of 2003. Reflection on the activities that had been incorporated in Phase II led to a number of modifications that made it possible to target a large number of students. Phase III, involving two action research cycles, targeted all students registered for the Mathematics Access Module. Phase III is described in Chapter 6.

The second set of action research cycles was related to an investigation into an alternative approach to formative assessment. This investigation began in 2001 and ended in 2003. It is described in Chapter 7. An alternative assessment project was implemented in 2001. The results were analysed and a number of modifications were made. The same assessment tool was used in 2002, with the planned modifications. Very few changes were made in the nature of the project for 2003. The project was marked differently each year, but it is unlikely that this had much impact on the way the students experienced the project. This set of action research cycles consisted of three cycles, spanning 2001, 2002 and 2003, respectively.

The research results emanating from these parallel sets of cycles gave rise to a final cycle, discussed in Chapter 9, which focused on diagnostic assessment. This cycle began in 2004, and ongoing research will lead to further cycles.

Within the action research framework outlined above it has been possible to study in a systematic way the effects of different interventions on the performance of students in the Mathematics Access Module. As was pointed out earlier, much of the data gathered within action research cycles can be regarded as information. However, at times specific variables were measured, and numerical data were captured. Each action research cycle could have been the subject of lengthy debate and extensive statistical analysis, but from the limited preliminary results available it seemed justified to continue to the next cycle, without analysing the data further. In most cases the first form of analysis undertaken was to determine whether it might be possible to predict or explain the value of one of the variables from the value of another variable. Only the simplest linear correlation was considered, with the intention that if such a correlation was found, further investigation could take place. The intention was not to ignore the fact that a complex array of inter-related variables played a role in each case. It was not the purpose of this thesis to document in-depth statistical analysis of the quantitative data available, although there were cases where further investigations, such as factor analysis or regression analysis, could have been carried out. In the writing of this thesis an assumption was made that if a linear relationship existed there might be a case for considering cause and effect; further analysis of the data could possibly be undertaken, and further research into specific variables or combinations of variables could also be carried out. The correlation statistics are provided simply 'to distinguish between chance occurrences and actual patterns in the data' (Gorard, 2001).

3.4 Factors affecting the study

The research described in this thesis was conducted over a period of seven years, from 1997 to October 2004[3]. A number of factors affected the process of making design decisions, and played a role in the conceptualisation and implementation of several interventions. The factors that affected this study and the context within which the research was carried out are discussed in the sections below.

3.4.1 Language of instruction

It was pointed out in Chapter 1 that in South Africa mathematics education at secondary level takes place in English or Afrikaans. This practice continues at tertiary level, which clearly places additional cognitive demands on students who are studying in a language other than their mother tongue. It was decided that the language of instruction for access level mathematics at UNISA would be English. Afrikaans as the language of instruction would have been totally unacceptable: the student uprising in 1976 was to a great extent provoked by the government decision that Afrikaans should be the only language of instruction for mathematics and science (EduSource, 1997). National Education Policy (Act No. 27 of 1996) establishes the right of 'every student to be instructed in the language of his or her choice, *where this is reasonably practicable*' (SAQA, 2004, italics added). While students may prefer to be taught mathematics in the mother tongue, this has not been feasible and they need to cope in English. Very few learners or teachers have English as their primary language, but at this stage there is no practical alternative for mathematics at higher levels. However, the problems that this creates should not be underestimated, in spite of attempts to deal with the problem by introducing language and cognition courses in the tertiary curriculum (EduSource, 1997).

[3] The thesis was completed in October 2004, and hence no 2004 examination results are included.

Even if provision of study material in all official languages were feasible for mathematics modules at the access level, it would only further widen the gap between students whose mother tongue is English (L1 students), and those for whom English is not the primary language (L2 students). The L1 students would then be in a position to move smoothly ahead into subsequent mathematics courses (locally or internationally), while L2 students would first still need to become proficient in English.

It is not the purpose of this thesis to debate the merits of investigating whether or not a mathematics discourse in the country's other official languages should be developed. The focus of the thesis is on the situation as it was during the period that access to mathematics at UNISA was being investigated, and as it will be for the foreseeable future.

3.4.2 The meaning of success

At several points in the thesis the idea of 'success' is put forward. It is clear that success can be considered in different and possibly intangible ways, such as a sense of personal satisfaction, increased awareness of what academic study entails, or greater understanding of the nature of mathematics. This thesis focuses on success as a measurable aspect of study, where performance in an assessment task, such as an assignment or examination, is considered. Limited contact with students who are geographically dispersed and who do not necessarily have access to technology dictates that examination results are the only reliable, albeit limited, measure of student achievement. We focus on this aspect, specifically the pass rate in the year-end examinations, as the criterion by which the various interventions in the research cycle, are regarded as being successful or not. (We note, however, that apart from 2000 there was no time at which an intervention was wholly independent of another intervention, or some other related activity.)

3.4.3 The role of selection and placement

It is also important to clarify that at the outset, when access initiatives were first considered at UNISA in 1993, any form of entry-level testing was regarded as gate keeping, and was unacceptable. When the access examination for mathematics was put in place, it was in essence a selection tool, in that successful students could then register for the Mathematics Bridging Module. The failure of the examination to deliver significant numbers of students led to the development of a fully-fledged access module (as we will see in Chapter 4), open to all students who had obtained a senior certificate[4]. In a sense the Mathematics Access Module

[4] The senior certificate implied passing the Grade 12 examination, without exemption.

was also a selection tool, which extended over the full academic year, and ultimately led to acceptance in the Bridging Module.

As the module evolved, diagnostic testing was eventually perceived as an essential pre-requisite to registration for the Mathematics Access Module, and the situation finally arose where entry-level testing was introduced. The philosophy thus changed from an acceptance of open access, to the recognition of the need for managed access through a diagnostic assessment process. Although placement or selection testing were and are common practice at other universities, this was not initially perceived to be an acceptable practice at UNISA, and the practice could not be implemented at the time that the initiatives described in the thesis were first introduced. The extent to which selection criteria and placement or diagnostic testing could play a role in the Mathematics Access Module was thus not constant during the period described.

3.4.4 Limited availability of meaningful data

During most of the 1990s matriculation results were not automatically sent to UNISA by the relevant authorities. Information for groups of students in specific courses was thus often unavailable; if information was available it was often incomplete or inaccurate. More recently the results are sent directly to the universities, and useful information is more readily available (Visser, Bureau of Management Information, UNISA, private communication). During the time that UNISA was developing its access initiatives, although learner profiles would have been useful the lack of meaningful data was problematic. Material was designed with a particular ‘target group’ in mind, but the needs were based on perceptions derived from limited interaction with students, rather than specifically established through research. In general, provision of access opportunities was a reaction to the large number of students who could not be accommodated elsewhere, either for financial or personal reasons (at UNISA students can register separately for specific modules, one at a time, if necessary), or through not meeting more stringent entry requirements.

As we shall see later, comparisons of results are made across years. Comparisons are only meaningful if the parameters remain constant; in an educational context the parameters are dynamic, in an essentially variable environment. Although theoretically we compare the mathematics results of students who have entered UNISA after matriculating, the concepts of entry, passing, and matriculation are loaded: some students enter UNISA immediately after leaving school, and others several years (even decades) later; in addition, passing the matriculation examination is affected by the year in which the examination was written. Research undertaken into the standard of questions in the senior certificate examination papers during the period 1992 to 2003 shows considerable variation in standards and, of particular concern for L2 students studying through the medium of English, a decline in the level of conceptual demand in the English Second/Additional Language examination paper (Umalusi Report, 2004). An analysis of the matriculation results of a particular cohort of students would thus have been of limited benefit.

In later chapters discussion of pass rates often includes a comment on the number of students who did not write the examination. Some of these students were not admitted to the examination (this is explained in Chapter 8), but over the years an increasingly large number of students registered, began to be involved in their studies, and then dropped out. There has been no general attempt to find out the reasons for this trend. Interaction with students suggests that financial and domestic circumstances may be contributory factors, but without the necessary data this remains speculation.

Documenting student history and past academic performance is a function of the Bureau for Management Information, but little relevant information reaches the academic departments unless specially requested; from experience when the requested information is made available it is often incomplete. When the university made the decision to widen access to mathematics, no plans for longitudinal research were put into place, either because of lack of foresight, or lack of staff time, or a combination of several such factors. As a result, an important issue which has not been investigated is the increasing rate of registration and simultaneously decreasing rate of success in the examinations, where 'success' is considered in relation to the number of students who write the examination, and the number of students who pass (as noted above). This phenomenon relates specifically to the Mathematics Access Module (which is described in Chapter 4). Pass rates in different first year modules, over different years, are available, but do not present a comprehensive picture of student performance: unless a significant amount of time and effort is invested, it will not be clear from the figures available whether a student who passed one module was a repeat student, a student in his/her final year taking a mathematics module to top up degree credits, a student also registered at a face-to-face institution taking a UNISA module in order to meet entry requirements for further study, etc. Analysis of results in any particular year thus did not take into account the 'bigger picture'.

Research with respect to voluntary tutorial class attendance at regional centres would have been useful to establish whether there was any significant correlation between examination results and tutorial class attendance. However, the Department of Student Support was unable to provide the necessary data, even though tutors are encouraged to keep attendance registers.

The premise was 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 at the time of writing this could not be verified.

3.4.5 Institutional factors

Initially access to mathematics at UNISA developed in an uncoordinated way, with activities undertaken by academic staff who had many other academic responsibilities. 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 that would be required to provide adequate levels of teaching and support if an open-door policy was followed. This lack of understanding 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 was aimed at all registered students. Support initiatives, which were not accessible to all students, were less well resourced. There was no systematic initial investigation into the needs of students, and no initial systematically planned research with regard to the interventions that were implemented, and their impact.

3.5 Summary

In this chapter we have seen that there was a pre-research phase involving the development of the Mathematics Access Module (see Chapter 4). It was followed by two parallel sets of action research cycles, both of which converged to one more action research cycle. Table 3.1 summarises the action research cycles.

Table 3.1:

Parallel sets of action research cycles

	Focus of intervention	
Year (*n*)	**Assessment (Project)** (Number of students who responded)	**Reading** (Number of students who responded)
2000 (800)		**Cycle 1 - Phase I** (308)
2001 (1 279)	**Cycle 1** (861)	**Cycle 2 - Phase II** (33)
2002 (1 425)	**Cycle 2** (894)	**Cycle 3 - Phase III** (Video 1) (165) Associated reading (78)
2003 (1 619)	**Cycle 3** (1 009)	**Cycle 4 - Phase III** (Video 2) (89) Associated reading (1 371)
2004 (1 518)	**Final cycle** **Diagnostic assessment** January (326) June (834)	

The number (*n*) in the first column reflects the number of registered students in each year. The numbers in parentheses in the other columns show the number of responses which could be analysed. The assessment intervention targeted all students in each cycle; the reading intervention targeted all students in the first, third and fourth cycles. Not all the targeted students responded in a measurable way.

We now move on to consider the development of the Mathematics Access Module at UNISA. The development was a dynamic process, involving several different activities such as selecting content, writing material, determining appropriate assessment mechanisms and providing support. Selecting content and teaching approach formed the pre-research phase, which is described in the next chapter to provide the context for the action research cycles that followed.